REPORT RESUMES

ED 010 377 56

INDIVIDUAL DIFFERENCES IN LEARNING FROM VISUAL AND VERBAL PRESENTATIONS AND THE USE OF VISUAL EXAMPLES IN REVIEW.

BY- GAGNE, ROBERT M. AND OTHERS
AMERICAN INSTITUTES FOR RESEARCH, PITTSBURGH, PA.

REPORT NUMBER BR-5-0425 PUB DATE DEC 65
REPORT NUMBER NDEA-VIIA-1073
REPORT NUMBER AIR-D73-12-65-FR
GRANT OEG-7-48-7670-206
EDRS PRICE MF-$0.18 HC-$4.96 124P.

DESCRIPTORS- *SCIENCE INSTRUCTION, INSTRUCTIONAL FILMS, INDIVIDUAL DIFFERENCES, *LEARNING PROCESSES, *VISUAL LEARNING, *VERBAL LEARNING, TEACHING METHODS, GRADE 8, *INSTRUCTIONAL MATERIALS, APTITUDE, AUDIOVISUAL AIDS, PITTSBURGH, PENNSYLVANIA

TWO DIFFERENT USES OF VISUAL REPRESENTATIONS FOR SCIENCE INSTRUCTION WERE INVESTIGATED. THE FIRST STUDY EXAMINED THE HYPOTHESIS THAT USE OF PICTORIAL INSTRUCTION WOULD PRODUCE HIGHER CORRELATION BETWEEN RESULTS OF VISUAL APTITUDE TESTS AND LEARNING TESTS, AND THAT VERBAL INSTRUCTION WOULD PRODUCE HIGHER CORRELATION BETWEEN RESULTS OF VERBAL APTITUDE TESTS AND RESULTS OF LEARNING TESTS. TEST RESULTS SHOWED NO DIFFERENCE IN CORRELATION OF VISUAL APTITUDE OR VERBAL APTITUDE TEST RESULTS TO LEARNING ACHIEVED. APTITUDE MEASURES USED WERE (1) SPATIAL RELATIONS, (2) VERBAL REASONING, (3) ABSTRACT REASONING, AND (4) INTELLIGENCE. THE SECOND STUDY USED PICTORIAL REPRESENTATIONS IN REVIEW SESSIONS, COVERING STUDY OF MECHANICAL ADVANTAGE TO INVESTIGATE (1) WHETHER RETENTION WAS IMPROVED BY USE OF PICTURES IN REVIEW AND (2) WHETHER INCLUSION OF ADDITIONAL DIFFERENT EXAMPLES WOULD INCREASE RETENTION AND TRANSFER. RESULTS SHOWED THAT STUDENTS WHO REVIEWED BY PICTORIALLY PRESENTED MATERIALS HAD SIGNIFICANTLY BETTER RETENTION AND TRANSFER OF TRAINING THAN STUDENTS WHO DID NOT REVIEW AT ALL. ADDING NEW PICTORIAL EXAMPLES PRODUCED NO SIGNIFICANT RESULTS IN RETENTION BUT SHOWED BETTER TRANSFER WHEN ONLY THE ORIGINAL MATERIALS WERE REVIEWED. RETENTION AND TRANSFER WERE MEASURED 4 WEEKS FOLLOWING THE REVIEW SESSION. (AL)

ED010377

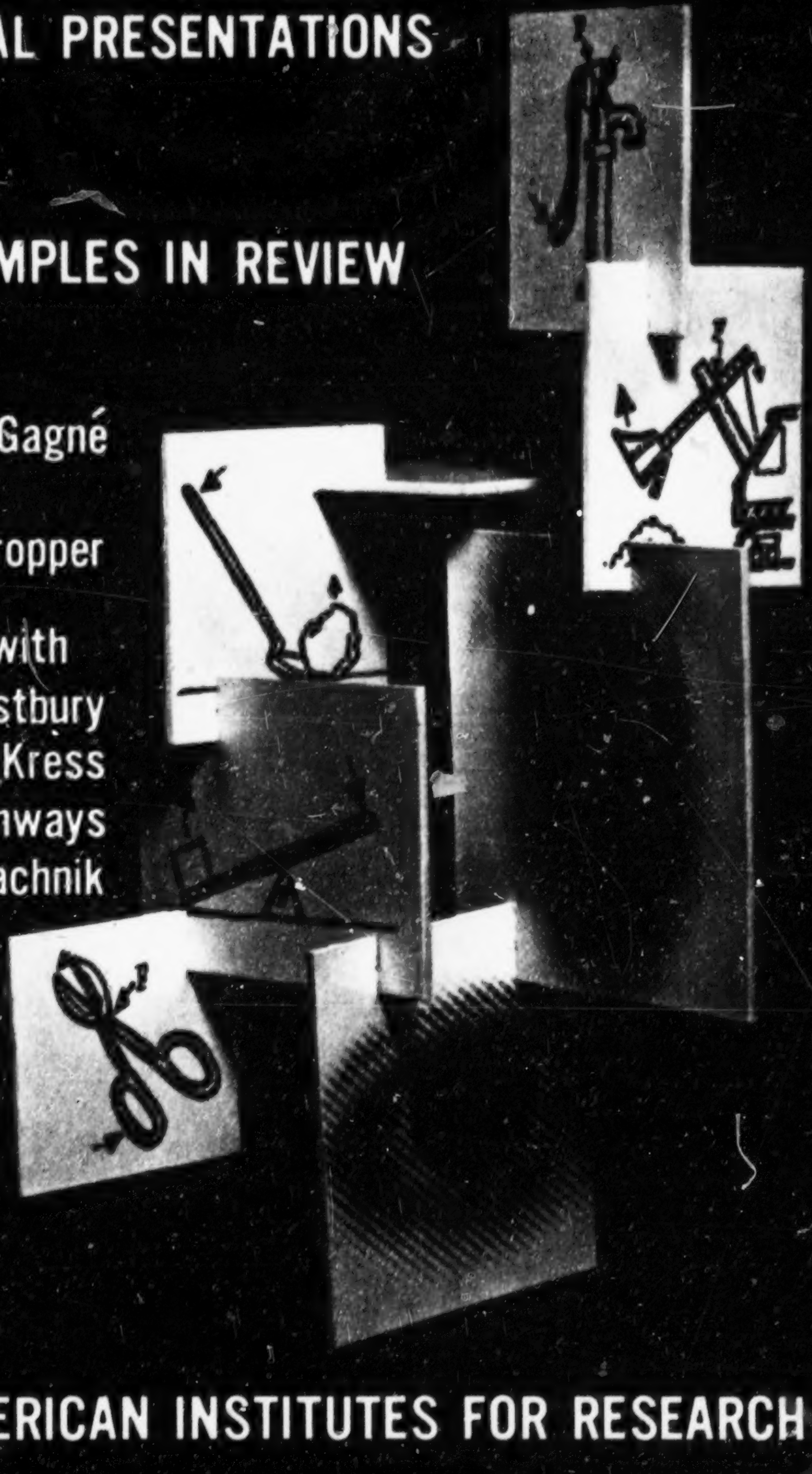
Studies in Filmed Instruction

1. INDIVIDUAL DIFFERENCES IN LEARNING FROM VISUAL AND VERBAL PRESENTATIONS

2. THE USE OF VISUAL EXAMPLES IN REVIEW

Robert M. Gagné
and
George L. Gropper

with
Christopher Astbury
Gerard C. Kress
Margaret C. Samways
Thomas Stachnik



AMERICAN INSTITUTES FOR RESEARCH

The research reported herein was conducted under the direction of Robert M. Gagné, Principal Investigator, and was supported by a grant from the U.S. Department of Health, Education, and Welfare Office of Education, Title VII Project Number 1073, National Defense Education Act of 1958, Grant Number 7-48-7670-206

VII A- 1073
(S-0425)

AIR-D73-12/65-FR

Studies in Filmed Instruction

1. INDIVIDUAL DIFFERENCES IN LEARNING FROM VISUAL AND VERBAL PRESENTATIONS AND

2. THE USE OF VISUAL EXAMPLES IN REVIEW

Robert M. Gagné
and
George L. Gropper

with
Christopher Astbury
Gerard C. Kress
Margaret C. Samways
Thomas Stachnik

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

AMERICAN INSTITUTES FOR RESEARCH
DECEMBER 1965

TABLE OF CONTENTS

ABSTRACT i

STUDY NO. 1

Individual Differences in Learning from Visual and Verbal Presentations

INTRODUCTION 1
METHOD 5
RESULTS 12
DISCUSSION 18

STUDY NO. 2

The use of Visual Examples in Review

INTRODUCTION 23
METHOD 25
RESULTS 28
DISCUSSION 30

REFERENCES 33

APPENDIX A-STUDY NO. 1
APPENDIX B-STUDY NO. 2

ABSTRACT

The studies reported in this volume concern two possible uses for visual demonstrations in science instruction. They were selected for study because of promising results in previous research studies, and because of their potential importance for the design of effective programs of instruction. The first of these possibilities is that individual differences in aptitude for learning may make pictorial presentations more effective for certain kinds of individuals than for others. For such people, materials that include visual demonstrations may be more readily learned than those which are mainly verbal in content. The second possibility is that the use of varied pictorial examples as portions of review lessons may enhance the retention of learned principles, or their transfer to novel problems. Accordingly, two separate studies, employing portions of instructional material in common, were designed to explore these two possibilities.

Aptitudes and learning from visuals. The first study investigated the relationships between selected individual differences variables, as measured by standard aptitude tests, and several learning variables. The aptitude measures employed were obtained from standardized tests of: (1) spatial relations; (2) verbal reasoning; (3) abstract reasoning; and (4) intelligence or IQ. A learning measure of particular interest was time-to-learn self-paced verbal materials which followed learning treatments that either contained or did not contain pictorial presentations.

Hypotheses examined were that higher correlations would be found between spatial (i.e., visual) aptitude scores and learning measures when pictorial instruction was employed; between verbal aptitudes and learning when verbal instruction was employed; and no differences in correlations of learning and abstract reasoning ability under the contrasted instructional conditions. Eighth grade students took part in the experiment, learning principles of mechanical advantage under experimental and control conditions.

Spatial and verbal aptitude measures were in general not found to be differentially correlated with learning measures of time-to-learn, achievement, or retention, under different conditions of presentation. Although some isolated instances of such differences in relationships were found, the general conclusion would appear to be that standard aptitude measures such as those employed in this study have not been shown to be successful in identifying a "match" between ease of learning for the individual student and pictorial vs. verbal mode of presentation. The suggestion is made that measures need to be designed to assess capabilities that are task-specific, if they are to predict the learning of different classes of materials. That is, it is possible that predictor measures may be derived by analysis from the particular class of tasks used in learning, whether verbal or pictorial. These, however, would represent capabilities of considerably greater specificity than what are usually referred to as "verbal" and "spatial" aptitudes.

Pictorial content in review. The second study used pictorial presentations in a review session following original learning of some principles of mechanical advantage. It was desired to investigate, first, whether retention of these principles would be enhanced by the use of review materials containing pictorial examples, and second, whether the inclusion of a variety of novel examples (as opposed to examples like those used in original learning) would have the effect of increasing retention and transfer. A group of eighth grade students was divided by random assignment into three subgroups of 24. Two of the groups took part in review sessions and the third, serving as a control, received no review. Measures of retention and transfer were obtained four weeks following the review sessions.

The results showed significant differences in retention for the groups having the pictorially-presented review examples, as contrasted with the group receiving no review. Similar findings were obtained when scores on transfer of training were compared. Significant differences were not obtained, however, in retention scores obtained following the two different experimental treatments involving "old" and "new" visual examples. In the case of transfer, results indicated the review session containing "old" examples (similar to those used in original learning) to be the most effective treatment, whereas the review involving novel examples did not produce transfer significantly greater than that obtained with no review. The conclusions to be drawn are, first, that pictorial presentations used in review are effective in improving retention and transfer. However, transfer effectiveness appears to derive primarily from practice of materials encountered in original learning, and thus to be dependent upon retention. The importance of this conclusion may lie in its relation to results on the importance of overlearning to retention. Overlearning involves practice of originally learned content, rather than application to new examples.

1
STUDY NO.

INDIVIDUAL DIFFERENCES IN LEARNING FROM VISUAL AND VERBAL PRESENTATIONS

INTRODUCTION

Those who seek to make optimal instructional use of audio and visual media are constantly faced with the problem of determining how such media may best be adapted to individual differences. It is frequently speculated that some students will learn more readily when material is presented in visual form than when the same material is presented in verbal form. This view seems consistent with still another notion of possibly older origin, that some people tend to "think visually" while others "think verbally," (cf. Galton, 1907). Although a fair number of studies have related visual and verbal presentations to such general measures as "intelligence," one can find little or no research evidence bearing upon the differential effectiveness of these different forms of presentation for people differing in visual and verbal abilities.

Visual presentations are often an integral part of science instruction. The demonstration of scientific concepts and principles in pictorial or demonstrational form is generally believed to be of value in instruction, and in fact to provide certain advantages over textbook or lectures. Aside from their effects in enlivening lectures, demonstrations are often considered to enhance science instruction in one or more ways leading to increased understanding and competence on the part of the student. This is thought to be the case whether such demonstrations are presented in "live" form or by means of films and television. An outstanding example of a modern instructional film series in physics developed by the Physical Sciences Study Committee contains a high proportion of films devoted to demonstrations of physical principles, which are intended to supplement, or in certain instances substitute for, the conduct of laboratory instruction.

There is no agreement on the reasons why visual demonstrations may possess an instructional advantage, nor on reasons why such an advantage may be different for different people. One prominently suggested possibility that deserves investigation is that differences in those individual dispositions called aptitudes may be related to the effectiveness of visual media. Generally speaking, an aptitude may be conceived as a general disposition to perform a great variety of functionally similar tasks. Thus, according to a commonly held view, the possession of high verbal aptitude means that an individual will perform well on any number of specific tasks having verbal content (such as reading for comprehension, writing compositions). Similarly, the possession of high visual (usually called spatial) aptitude implies that the individual will perform well on specific visual tasks (such as interpreting a three-dimensional drawing). Presumably, this means that spatial aptitude, conceived as a general ability, will be positively related to specific tasks of learning via visual presentations.

Some aptitude-achievement findings. Certain rather general suggestions regarding the relation of individual aptitudes to achievement following film or television presentation come from previous investigations. These studies have been reviewed by Hoban and van Ormer (1950), by Carpenter (1953, 1960), and more recently again by Hoban (1960). Many of these studies report substantial positive correlations between achievement and measures of general intelligence, more or less unaffected by the mode of presentation (pictorial vs. lecture or text) employed. Some findings have tended to show that individuals of lower IQ exhibit greater gains from pictorial instruction than from non-pictorial modes; this is true of studies by Kanner, Runyon, and Desiderato (1954); by Gibson (1947); and by Vernon (1946), among others. Gropper (1965a) found evidence that a low IQ group learned more from material on scientific concepts when these were presented pictorially than when they were presented verbally. In addition, this study showed an advantage for pictorial as opposed to verbal response options for this group.

Various suggestions have been advanced as to the reason for such findings. The most obvious may be that people of low verbal aptitude have greater difficulty learning when materials are presented verbally in abstract form. Another possibility is that pictorial presentations, besides being concrete, are more vivid and stimulating, and thus tend to capture the attention and interest of slow learners to a greater extent than lectures or texts. Up to the present time, research has thrown no greater light on the problem than this.

Differential aptitude predictions. One theory of aptitude measurement, with which we are concerned here, holds that an aptitude is a general ability that is related to a number of specific human performances of the same general class. That is, verbal aptitude is considered to be an ability that affects the ease or rapidity of learning of tasks containing verbal materials, or tasks in which the content is conveyed by primarily verbal means. In an analagous fashion, spatial aptitude is conceived as an ability that affects the ease of learning of pictorially-presented tasks. Travers (1954) defines aptitudes as abilities to make the discriminations that are necessary in order to profit from instruction. Following such a definition, one would expect that high spatial aptitude means that an individual already has the visual world of distances, shapes, sizes, and directions well differentiated, so that a specific pictorially-presented task requires little additional learning for competent performance. Similarly, an individual with high verbal aptitude has, according to this idea, a head start on the discrimination of verbally presented materials contained in a particular verbal task.

In view of the current state of technical knowledge concerning the varieties of human aptitudes (cf. Anastasi, 1961; Guilford, 1956), it is somewhat surprising to find a dearth of studies which have attempted to relate these different aptitudes to learning outcomes associated with visual presentations. Verbal aptitude, it is true, has frequently been mentioned as a prominent component of the IQ. But studies have not attempted to separate out the possible differential relationships of the effects of pictorial presentations with aptitudes other than verbal. A contrast has not been drawn between the effects of such relatively distinct aptitudes as spatial and verbal, despite the possible relation these may have to learning tasks which emphasize pictorial and verbal materials.

Purpose of the study. The purpose of the present study is to explore the differential effects verbal and spatial aptitudes might have on learning from verbal and pictorial instructional media. As reference variables, other measures of aptitude are also included. One of these comprises "IQ equivalence" scores from a group intelligence test, providing a composite measure of ability predictive of success in learning school subjects. The other is abstract reasoning, an ability thought to be related to intellectual power, which is, however, not heavily weighted with either "visual" or "verbal" components.

The hypothesis to be investigated, stated generally, is that visual or verbal presentations have greater instructional effectiveness when they build upon previously established areas of discriminative capability (measured as spatial or verbal aptitude) within the individual. As previously pointed out, high scores in spatial aptitude carry the implication that learning by means of pictorial presentation will be easy; high scores in verbal aptitude imply that learning with verbal presentations will be easy. Relationships with intelligence scores, it is expected, may be substantial, because of their somewhat broad-ranging aptitude coverage, but not markedly different under pictorial or verbal instructional conditions. In contrast, relatively low correlations are hypothesized with the purely intellectual measurement provided by abstract reasoning, but no differences related to visual _vs_. verbal presentations. The various hypotheses may be summarized as follows:

(1) Higher relationships between spatial aptitude and learning will be found for pictorial presentations than for verbal presentations.

(2) Higher relationships between verbal aptitude and learning will be found for verbal presentations than for pictorial presentations.

(3) Abstract reasoning ability will be related to learning from pictorial and from verbal presentations to an approximately equal degree.

METHOD

Experimental Design

The study was designed to determine the magnitude of the correlations that exist between specific differential aptitudes and performance under different types of learning conditions.

Independent variables. The primary experimental comparison was between a visual (pictorial) lesson and a verbal lesson, each dealing with "mechanical advantage" in first class levers. Mode of presentation was thus the one independent variable that was experimentally manipulated, resulting in two experimental conditions.

Several individual difference measures, obtained from scores on paper and pencil tests, also served as independent variables. Besides IQ, the specific aptitude measures employed were derived from the following Differential Aptitude Tests: Space Relations, Abstract Reasoning, and Verbal Reasoning.

Dependent variables. Dependent measures consisted of learning, i.e., time taken to complete a self-paced verbal lesson that followed the original learning of either pictorial or verbal material; and achievement scores on tests measuring both retention and transfer.

The general form of the design was as follows:

Group 1	Group 2
visual program (fixed-paced on film)	verbal program (fixed-paced on film)
self-paced verbal program	self-paced verbal program
immediate and delayed tests of retention and transfer	immediate and delayed tests of retention and transfer

Experimental Procedure

All subjects received identical pre-experimental treatment designed to provide a common background and level of prior knowledge that was relevant to the concept of the mechanical advantage of first class levers. All students observed the following general schedule, with minor variations to accommodate prior commitments in participating schools.

Pre-experimental sessions (in the schools):

Week 1 - Administration of pretest on mechanical advantage; and administration of aptitude tests.

Week 3 - Administration of a self-paced program on "force and motion."

Week 4 - Administration of self-paced program on an "introduction to levers."

The experimental sessions followed the last pre-experimental session by one week.

Experimental sessions (in the studios of WQED):

Week 5 - Administration of experimental lessons.

Group 1 - fixed-paced *visual* demonstrations on film; followed by self-paced verbal lessons in booklet form; segments of the fixed-paced visual lessons were serially intermixed with segments of the self-paced verbal lessons.

Group 2 - fixed paced *verbal* presentation on film, covering the same concepts in the visual version; followed by the self-paced verbal program used by Group 1, with segments serially intermixed.

Group 3 - control group; no fixed-paced film presentation; self-paced verbal program used by other groups, only.

An *achievement test* was administered to all groups immediately following the learning session.

Retention measurement (in the schools):

Week 9 - Administration of a test to measure *retention*.

Individual Difference Measures

The principal individual difference measures used were the Otis IQ, obtained from school records, and the following Differential Aptitude Tests (DAT): Space Relations, Verbal Reasoning, and Abstract Reasoning. The aptitude tests were administered in the schools by the project staff.

Pre-Experimental Programs

Two pre-experimental programs were designed to bring all students up to a comparable level of prior knowledge about concepts and principles on which an understanding of mechanical advantage would depend. One program covered the concepts of "force and motion;" the second was an "introduction to levers."

Pre-experimental programs and the verbal experimental programs (described below) were prepared in the REP style developed by Gropper (1965b). Briefly, R-E-P stands for Recognize, Edit, and Produce, and describes the sequence of response mode requirements given the student. The discriminations and generalizations on which the learning of concepts is contingent were acquired first on the basis of recognition of multiple-choice responses. Then, students practiced editing verbal statements. This required them to discriminate between correctly and incorrectly used concepts; when incorrect, they were required to correct them. Not until this stage was completed were students required to produce responses. For example, they were required to make up sentences from key words supplied, with other key words deliberately withheld. Their task was to produce a complete sentence and in so doing to produce the key phrases or words that would properly relate the given terms. Production frames also included conventional completion responses.

Criterion frames in the REP programs consisted of make-up-a-sentence task or of the more conventional completion frames, requiring the production of a fairly long, complex response. These frames required the student either to reproduce a principle in his own words or to apply it to a concrete problem.

Experimental Programs

There were three types of experimental programs, a verbal self-paced program, a fixed-paced visual program, and a fixed-paced verbal program. The verbal, self-paced program taken by all students, was also prepared in the REP style and was prepared in seven segments with each segment covering one or two concepts or principles. A fixed-paced verbal program on film was designed to parallel the visual program. It was administered preceding the self-paced verbal program for those students in the experimental treatment requiring it. The content of the two verbal programs is given in Appendix A, starting on pages 1 and 32.

Visual program. Pictured demonstrations illustrating concepts and principles that define what is meant by mechanical advantage were programmed. The presentation was preponderately pictorial (e.g., raising loads at one end of a board by pushing down at the other end). When words were used, they merely described, but did not explain, what was occurring. Technical explanations were given in the succeeding self-paced verbal program. The procedures used in programming these demonstrations were those developed by Gropper in his studies on the use of visuals (1965a). In this approach, students practice making discriminations about demonstrational events, their responses consisting of the selection of multiple-choice pictorial options. Through such responding to pictorial (demonstrational) stimulus events, students acquire relevant concepts and principles. The technique may be illustrated by a brief description of each of the seven visual segments.

Segment 1. This segment was designed to teach the student that the force required to lift an object, whether by hand or with a lever, has to be equal to the weight of the object.

First, it was demonstrated that a scale can measure the size of a force; a hanging scale attached to a hook on a wall was pulled and the strength of the force labelled as being of x magnitude. Then, with the aid of a hanging scale, students were shown that an object weighing x pounds required an x lb. reading on the scale (lifting force) to be able to raise the object by hand. Students were then required to predict where the pointer on the scale would have to be if a y lb. object were to be raised. Pictorial response options included a y reading, a less than y and a more than y reading. (Pages of the response booklet are reproduced in Appendix A, page 27.) A similar series of illustrative and practice demonstrations was used to teach the students that the lifting end of a lever must apply an x lb. force (x lb. reading on the scale) to lift an x lb. object.

Students thus practiced making discriminations among the scale positions required for an object to be lifted. By practice with a sufficient number of such examples they learned the principle concerning the required equality of a lifting force and an object's weight.

Segment 2. This segment was designed to teach students that the force applied to one end of a lever can be smaller than the lifting force applied to the load on the other end. For this purpose, hanging scales were attached to either end of a board, which was rotated around a fulcrum. As in segment 1, a demonstration was used to point out a relationship, in this case, the difference between scale readings at the applied and lifting ends of a lever. Students were then expected to predict what scale readings would be for other examples, e.g., whether the applied force would be less than, equal to, or more than the lifting force.

Segment 3. In this and all succeeding segments, as in segments 1 and 2, one or more examples preceded problems requiring students to respond actively. Segment 3 was designed to teach students about the ratio of applied force to lifting force. The student's problem was to indicate how many blocks would be raised at the lifting end if n number of blocks were placed on the applied end -- given a particular ratio of applied force to lifting force.

Segment 4. Just prior to the fourth visual segment, the third verbal segment had taught the meaning of the term mechanical advantage. With differing number of blocks at either end of the first class lever shown on the screen, students had to solve the following problems in visual segment 4: (a) they had to indicate what the mechanical advantage of the lever was for a given combination of blocks at either end, e.g., 2 and 8; (b) given the mechanical advantage and the number of blocks at the applied end, they had to select from pictorial options how many blocks could be lifted at the other end; and (c) given the mechanical advantage of a lever and the number of blocks at the load end, to indicate how few blocks at the other end would lift the load. This segment was intended to teach the mathematical relationship between the magnitude of the applied force, the weight of the load, and the mechanical advantage of a lever.

Segment 5. With the use of blocks again, this segment was designed to teach students the relationship between the position of the fulcrum and the change in ratio of applied force to lifting force. Students were required, in one problem, to predict where the fulcrum would have to be moved if a number of blocks smaller than the number used in demonstration were to lift the same load. Then, in another problem, they were required to predict how many blocks would be required to lift the same load when the fulcrum was moved.

The fifth segment also was designed to teach students the relationship between the ratio of lever-arm lengths and the ratio of applied force to lifting force. Given an example of a lever with ratio of arm lengths k/j (ratio of forces j/k), they were required to predict the number of blocks that would be lifted given a lever with a ratio of arm lengths m/n, the applied force being p.

Segment 6. In this segment, two levers were shown, each having a different number of blocks at either end. The problem put to the student was one of computing the mechanical advantage of each lever (by relating the number of blocks at the lifting and applied ends); and as a second problem, to indicate which lever of a pair had the larger mechanical advantage. This segment was thus designed to expand on the student's understanding of mechanical advantage.

Segment 7 continued the approach used in segment 6. In both segments, students were required to solve problems relating mechanical advantage, applied force, and lifting force. Through practice with the various examples, students could learn that a larger load could be lifted by a lever having a larger mechanical advantage (applied forces being the same for both); or that a larger load could be lifted by the lever to which the larger applied force was applied (with mechanical advantage constant), and other principles of this sort. This segment was designed to teach the relationships among the three terms in computational terms. Responses to these problems were based on pictorial options.

All visual segments, it can readily be appreciated, relied almost exclusively on concrete events and objects to teach new concepts. Technical language was used during demonstrations only after it had appeared in the verbal programs taken prior to the particular visual segment. Concept acquisition was thus based on discrimination practice about relationships presented in concrete, pictorial form.

Achievement Test

The achievement test used immediately following the experimental learning session consisted of items highly similar to those used in the programs. It also contained transfer items using levers other than a straight board. The content of the test is given in Appendix A, page 44.

Retention Test

The same achievement test was used again to measure retention, four weeks later. The test was administered in the schools.

Subjects

The subjects were eighth grade students from the city and Diocesan schools of Pittsburgh. Students were assigned at random to the three experimental conditions. Correlational analyses were based on 46 subjects in the pictorial treatment group, 42 in the verbal treatment group, and 45 in the control group. Variance analyses were based on a total of 95 subjects matched for IQ and time-to-learn.

RESULTS

Aptitudes and learning measures. The correlations between aptitude and certain learning variables of major importance to the present study are summarized in Table 1, taken from the complete matrixes contained in Appendix A, page 56. This table makes it possible to compare the correlations of each learning measure with each aptitude measure, under "pictorial," "verbal," and "control" conditions of instruction. By reading the table across each row, a comparison of correlations is provided under these three conditions of presentation. Reading down each column permits the comparison of learning vs. aptitude correlations for the different aptitudes (verbal, spatial, abstract reasoning, IQ) under one condition of presentation at a time.

TABLE 1

Correlations Within Each Experimental Group
of Learning Variables vs. Aptitude Variables

		Conditions of Instruction		
Learning Variable	Aptitude	Pictorial (N=46)	Verbal (N=42)	Control (N=45)
Learning[1] Rate	Verbal	.321	$.286^+$	.155
	Spatial	.221	$-.134^+$	-.114
	Abstr. Reas.	.009	-.029	-.063
	IQ	$.467^*$	.142	$-.178^*$
Achievement	Verbal	.457	.482	.510
	Spatial	.366	.346	.436
	Abstr. Reas.	.412	.457	.344
	IQ	.181	.309	.449
Retention	Verbal	.355	.479	.470
	Spatial	.295	.093	.350
	Abstr. Reas.	.393	.215	.294
	IQ	.157	.217	.331

[1] Correlations with time to learn are sign reversed; *differences between marked correlations in this row are significant at the .01 level; +differences between marked correlations in this column are significant at the .01 level.

The variable of learning rate, measured as time to complete self-paced programmed materials, is of major interest in the present study. The programmed materials used for the measurement of results of experimental treatment were verbal in composition. They were carefully pre-tested and revised to produce high achievement for high proportions of the learners. Accordingly, rate of learning was considered to be the major indicator of success of any previous learning treatment. Generally speaking, with exception to be noted, the correlations between learning rate and aptitude were fairly low and not significantly different from each other. Specifically, looking across the first row of the table, no significant difference in correlation is found between verbal aptitude and rate of learning following "verbal" instructional conditions, as compared with those correlations found following other conditions.

Similarly (row 2), there is no significantly higher correlation between spatial aptitude and rate of learning following "pictorial" conditions of presentation than occurs under other conditions. Correlations between abstract reasoning (row 3) and rate of learning are uniformly low.

However, one of the differences among the correlations of IQ with learning rate is a significant one, and worthy of note. The highest correlation (.467) occurs in the group which learned under visual conditions. This correlation is significantly different from zero, and as shown in Table 1, from that obtained in the control condition. Although under most learning conditions, learning rate correlates to a low degree with all aptitude measures, when pictorial conditions are employed, this exceptional correlation is obtained.

To continue with an examination of differences among correlations of aptitude with learning rate, one significant difference (top, middle column) occurs between the size of relationship of learning rate to verbal aptitude under verbal conditions of instruction, and with spatial aptitude under the same (verbal) conditions. Here the difference is entirely in the expected direction. When instruction is given by means of verbal presentation, verbal aptitude relates more highly to learning rate than does spatial aptitude. This finding is in accordance with hypothesis (2) as previously stated. When verbal presentations are used in instruction, measures of verbal aptitude predict how rapidly students will learn, to a greater extent than do other aptitudes.

Turning to the next block in the table, it may be seen that achievement (score on the immediate post-learning test) is correlated with all the aptitude measures, nearly always to a moderate degree. Virtually all of these correlations are significantly different from zero. Perhaps most noteworthy is the small correlation (.181) of IQ with achievement under pictorial instruction conditions, since it contrasts with the relationship previously noted of IQ with learning rate (.467).

The retention measure correlates moderately (and significantly) with verbal aptitude under each condition of instruction, but not differentially among these conditions. Lower correlations are obtained between retention and spatial aptitude, retention and abstract reasoning, and retention and IQ, than is the case for retention and verbal aptitude. No doubt the verbal nature of the test used in retention is mainly responsible for the higher trend of relationships with verbal aptitude. No significant differential effects of instructional conditions can be found among these correlations.

Relations among learning measures. The correlations obtained among some of the more important learning measures used in the study are shown in Table 2. The significant differences between various pairs of measures are indicated.

Looking first across the rows of the table, one is struck first of all with the absence of evidence for differential effects of the conditions of instruction on these correlations. The sole exception, previously noted in Table 1, and shown here in row 1, is the correlation of IQ scores with learning rate under pictorial conditions of instruction, as contrasted with the correlation obtained under other conditions. The suggestion here is that the rate of learning under pictorial conditions comes to depend upon IQ to a greater extent than is true under other conditions. In other words, visual presentation of the sort used in this study has a tendency to depend for its effectiveness (in improving learning rate) on intelligence, to a greater extent than is true with other kinds of instructional conditions.

TABLE 2

Correlations Within Each Experimental Group Among Different Learning Variables and IQ

		Conditions of Instruction		
Variable	Learning Variable	Pictorial (N=46)	Verbal (N=42)	Control (N=45)
IQ	Lng. Rate[1]	$.467^{*}$	.142	$-.178^{*+}$
	Achievement	.181	.309	.449
	Retention	.157	.217	.331
Lng. Rate[1] on Pre-Exp. Materials	Lng. Rate[1]	$.612^{+}$	$.649^{+}$	.477
	Achievement	.149	.213	.423
	Retention	.187	.016	.274
Pre-Exp. Achievement	Lng. Rate[1]	-.006	.123	.309
	Achievement	.352	.419	.383
	Retention	.364	.093	.233
Achievement	Lng. Rate[1]	$.187^{+}$	$.120^{+}$	$-.044^{+}$
	Retention	.825	.563	.753

[1] Correlations are with time to learn, sign reversed; *differences between marked correlations in this row are significant at the .01 level; $^{+}$differences between correlations with learning rate, as compared with correlations with the other variables, are significant at the .05 level.

Two measures obtained prior to the experimental sessions are included in the table as major variables of interest. A measure of time to learn (learning rate) was obtained on pre-experimental programs which were self-paced and verbal in nature. In addition, a measure of achievement was obtained on a test applicable to these pre-experimental materials. By examining the columns within sections of the table, one obtains a strong impression of the contrast between the intercorrelations of these two pre-experimental variables with learning rate (i.e., one of the main dependent variables of the experiment) and the intercorrelations of these same variables with achievement (post-experimental) and retention measures. For example, learning rate on pre-experimental materials correlates substantially with learning rate measured following the experimental treatment under all of the conditions; but the same measure correlates with achievement and retention scores to a significantly lower extent in both experimental groups. Pre-experimental achievement, in contrast, is related with post-experimental achievement and retention measures to only a moderate degree, and with post-treatment learning rate to a small degree. Finally, the post-treatment achievement scores show very low correlations with post-treatment learning rate, but significantly higher ones with the retention measure. In sum, so far as measures of learning are concerned, it appears that one is dealing with two distinct types, which are not closely related to each other. On the one hand there is learning rate, which shows a strong tendency to remain stable from one learning task to another, as has been found in previous studies (Kress & Gropper, 1964). On the other is achievement, measured either immediately or as retention after an interval; this measure is not at all highly related from task to task, although it is not unreliable when measured on the same task at two different times. These two variables -- learning rate and achievement -- however, show very low relationships to each other.

Effects of instructional conditions. The performance measures of learning rate, errors, achievement, and retention were examined by means of analysis of variance techniques with instructional conditions (visual, verbal, control) and aptitude measures (spatial, verbal) treated as independent variables. This resulted in a 3x2x2 analysis.

For the achievement measure, instructional method effects were apparently present but did not attain significance. The achievement test had a total possible score of 63. Mean differences for the methods of instruction were in the following order: pictorial highest (M = 40.2, S.D. = 6.9), then verbal (M = 38.1, S.D. = 8.0), and finally control (M = 36.1, S.D. = 8.7), which is consistent with some previous findings (Gropper, 1965a). For retention, a similar state of affairs was revealed, yielding the same order of mean differences. (In the order pictorial, verbal control: M = 38.9, S.D. = 7.3; M = 34.9, S.D. = 8.0; M = 35.2, S.D. = 9.4.) Effects of verbal aptitude were found to be significant, as was previously suggested by the correlational data of Table 1. For this comparison, F = 7.37, df 1 and 84, P $<$.01. However, there was no significant interaction between aptitude and instructional method variables.

No significant differences were found in the means of number of errors made in the experimental program, obtained following different experimental treatments.

Turning to the measure of learning rate, significant differences were found for the instructional method variable. In this case, F = 3.64, df 2 and 84, P $<$.05. The mean scores of time to complete the program were in the following order: verbal method (M = 75.2, S.D. = 8.9), control (M = 77.6, S.D. = 7.0), and pictorial method (M = 80.6, S.D. = 7.9). There is probably a reasonable relation between these findings and the previously reported correlations. In general, the use of the pictorial method slowed down the learning of subsequent verbally programmed material. It may be supposed that it "required more intelligence" to learn the verbally-presented material after having learned preceding material by visual means. No significant interaction was found between instructional method and either spatial or verbal aptitude.

DISCUSSION

The results can perhaps first best be discussed in terms of the hypotheses this research was designed to test.

1. Higher relationships between spatial aptitude and learning will be found with pictorial presentation than with verbal. The correlational evidence does not support this hypothesis. The correlations of spatial and verbal aptitudes with learning measures range from low to moderate, but are not significantly different from each other under the pictorial instruction conditions. There is, however, a significant difference in the correlations of learning rate *vs*. verbal aptitude and learning rate *vs*. spatial aptitude, under the *verbal* condition of instruction, indicating that the latter condition tended to be better for those individuals with high verbal aptitude.

2. Higher relationships between verbal aptitude and learning will be found with verbal presentation than with visual. Some partial evidence was found of the correctness of this hypothesis. The verbal method of instruction was superior in facilitating later verbal instruction, as measured by *learning rate*. However, when achievement and retention were measured, the pictorial method ranked highest, in a non-significant comparison.

3. Abstract reasoning ability will be related to learning to a relatively low degree, and about equally under pictorial and verbal presentation. No evidence against this hypothesis was found. In general, correlations of learning scores with abstract reasoning scores ranged from low to moderate, but were not strikingly different from those with other aptitudes.

Generally speaking, then, correlations obtained between aptitudes and learning variables did not show evidences of being different under different methods of instruction. Interpretation of this finding and its generality must take note of several factors in the situation. For one thing, it will be recalled that the instructional lessons were carefully programmed, and pre-tested, in order to insure that a high percentage of students mastered them. The individual differences measured under these conditions are in a sense residual ones, and are presumably small in comparison with those which might appear under conventional instruction. Such a procedure was nevertheless deliberate, because a fairly severe test of the idea of different learning "styles" was desired. Its effect, however, must have been to reduce the variance of learning measures, and thus to produce lower correlation coefficients. Second, it may be noted that the pictorial instruction given was of the sort designed to establish precise concepts by contrasting differentiating cues. This is not the only kind of pictorial instruction which might be used. Gropper (1963, 1965a) has distinguished several different functions that may be served by visual instruction.

Despite these limitations, there seems to be no particular reason why aptitude-instructional method interactions could not have been revealed by this study, if they truly existed. While it cannot be concluded that such relationships do not exist, one is inclined to say that the strategy of searching for relations of learning measures with aptitudes (as they are traditionally measured) is not a promising one. As Cronbach and Gleser (1965) put it, the regression lines relating aptitude to payoff for the different treatments do not cross, and therefore do not provide a useful basis for choice of instructional method.

Some implications. If aptitudes do not provide a basis for differentially prescribing instructional methods, might other kinds of individual differences serve this purpose? This is believed to be a likely and worthwhile possibility. After all, aptitudes of the sort measured in this study are considered to be abilities of quite a general nature (i.e., related to many varieties of specific tasks). What about some individual differences of a more specific sort? It would appear that such differences exist and are capable of measurement. Such individual differences variables may be described as task-specific (by which is meant, specific to a rather narrowly circumscribed class of tasks). They are not usually measured as "aptitudes." However, there are reasons to believe they might be the kinds of differences which are differentially related to such instructional methods as "pictorial" and "verbal" ones.

Some of the task-specific differences which may exhibit differential relations with learning measures in visually presented instruction are as follows:

1. Ability to abstract a class concept from visually presented object exemplars of the class. For example, in the material used in the present study, the concept "effort force" is taught by means of a pictorial presentation. A measure of correct identification of a number of different representations of effort force, following a single visual presentation of this concept, would seem to be possible to devise.

2. Ability to make and maintain discriminations of visually presented objects by multiple cues, when varied examples are shown. Perhaps the simplest illustration of this function in the materials of the present study is the Class 1 lever. It should be possible to design a measure of discrimination of such a lever from other arrangements of potential "arms" and "fulcrums" which do not, however, represent Class 1 levers. The appearance of such objects, both correct exemplars and incorrect ones, could be varied extensively in other dimensions.

3. Ability to resist interference in the face of frequent reversals of cues in object identification. Resistance to interference as an individual difference may be expected to have an effect on retention of learned concepts and concept discriminations. In relation to the materials of this study, such a measure might be derived by requiring identification of correct and incorrect representations of lever balance, when frequent reversals are introduced of the number of weights (i.e., amount of force), the side of the lever on which they are placed, and the relative lengths of the two lever arms.

4. Ability to code unfamiliar figures for retention (similar to "visual memory"). Such an ability does not seem to be prominently involved in the visual presentations used in this study, but is mentioned here for the sake of completeness. It is conceivable that a visually presented learning task might require the learning of separate identifications (or names) for a number of different forms or spatial arrangements. For example, the learner might need to acquire identifications of the three different classes of lever. His ability to code these (or a larger set of differing figures) differentially could be measured by his retention of them following a brief presentation of the entire set.

5. Ability to identify correct verbal statements of principles from visually presented specific examples. This ability involves visual to verbal "translation." Distinguishing correct from incorrect verbal statements of a visually presented relationship is the kind of measure suggested. In the present study, an example would be provided by the verbally stated principle relating force and length applicable to one arm of a balanced lever to that of the other arm.

These are some of the ways, and perhaps the important ways, in which individuals might be expected to differ from each other in learning brought about by visually presented instruction. A comparable set of abilities can readily be stated applying to verbal instruction. It is apparent that although certain resemblances can be seen with tests of aptitude, the measures suggested by these descriptions do not resemble aptitudes as usually conceived. The kinds of abilities implied have a definite resemblance to Travers' (1954, p. 8) definition of abilities "to make the discriminations which are necessary to profit from training." However, it is not clear that conformity to this definition is complete, since some of these dispositions might not properly be called discriminations.

It is of some importance to point out that the pursuit of research on relationships between instructional methods and individual differences variables of the "task-specific" sort would depend on the development and tryout of new kinds of tests, of the sort which have usually been discarded by those interested in aptitude measurement because of their "too specific" nature. No shortcuts to the testing of hypotheses of the sort suggested here can be seen. Instead, it would be necessary to exclude from consideration whatever is already known about the relationships among traditional aptitude tests. This is not to suggest that some clarification of the relationships between aptitude tests and newly designed "task-specific" measures would not ultimately be attainable.

Our most general conclusion is, therefore, that individual differences that are correlated with different methods of instruction, and represent what may be called "learning styles" need to be sought in measures which are more specific than those yielded by traditional aptitude tests. Dispositions that are "task-specific" to pictorially or verbally presented learning tasks appear to offer promise for this purpose. Since such differences have not usually been measured, there is currently no body of evidence providing support for this point of view.

2
STUDY NO.

THE USE OF VISUAL EXAMPLES IN REVIEW

INTRODUCTION

There are a number of imaginable ways in which visually-presented instruction might be expected to influence the effectiveness of learning, several of which have been described by Gropper (1963, 1965a). Besides their effects during the phase of acquisition, other possible outcomes resulting from the use of visual presentations are improved retention of what is learned, and as a somewhat related matter, improved transfer of learning to novel situations. It seems possible that visual presentations might help to establish in the learner memorial states that are visual in content, as opposed to being verbal; and that these may be easy to recall, as suggested, for example, by the use of visual images as coding devices in "memory systems."

Summaries of research on film and television presentations by Hoban and van Ormer (1950) and Carpenter (1960) include descriptions of studies which have employed measures of retention as well as achievement immediately following learning. Schramm's (1962) more recent article also discusses the results of such studies. In general, the findings have shown that gains relatable to the use of visual presentations in many kinds of learning tasks persist over periods of weeks and months. When visual presentations have been found to be superior to text or lecture, such differences are found to persist when retention is measured at a later time (Gibson, 1947; Rulon, 1933; Vernon, 1946; Kanner, Runyon, & Desiderato, 1954).

The effectiveness of brief review of material interspersed at intervals following its initial learning is an accepted fact (McGeoch & Irion, 1952). Yet few if any investigators have considered the direct effects which visual presentations may have on the retention process. There is certainly a good theoretical reason for expecting that visual demonstrations may have such an effect. As Gropper (1963) points out, retention of principles illustrated in visual form may be less subject to interference than the same principles in verbal form.

Of particular interest in connection with the use of pictorial presentations for review purposes is the introduction of variation in the visual examples used to teach a concept or principle. A presentation of review materials can emphasize the application of learned principles to the same class of situations used for original instruction, or, alternatively, it can emphasize application to new and different situations. There are many suggestions in the literature on learning research that the latter procedure may serve to enhance recall. Furthermore, varying the examples used for review may also have the effect of aiding transfer of learning to new situations.

The need was seen for a study that tested the effects on retention and transfer of visually-presented review materials administered following an initial learning period. The principles contained in the original lessons and in the reviews would be concerned with the physical principles of mechanical advantage. One group of students would review these principles via a visual presentation using the same examples as those employed in original learning. A second equivalent group would respond to a review presentation illustrating the same principles of mechanical advantage, but involving a variety of examples that had not been seen before. A control group of students would receive no review. At an interval following the review session, each group would be examined by means of a test which had two separable portions, one providing a score for retention, the other a score for transfer of training. In the former case, the items would pertain to the same class of situations used in original learning, although they would not be identical with these. The transfer items, in contrast, would use situations that were outside this class, to which the principles of mechanical advantage were applicable.

The questions posed by these experimental arrangements may be stated as follows:

1. Is retention of science principles enhanced by a review involving application of principles to visually presented examples?
2. Are retention and transfer improved more by the inclusion of novel examples in the review than by examples drawn from the same class as those used in original learning?

METHOD

Experimental Design

Independent variables. The experiment was designed to determine the effect that various types of visual review sequences would have on retention and transfer. The specific experimental comparisons made were among the following review conditions: (a) review with a visual (demonstrational) lesson used in original learning; (b) review with a visual lesson illustrating the same concepts and principles covered in the original lesson but using novel demonstration examples to do so; and (c) no review. The primary independent variable was the type of review -- with three treatments assessed.

Two individual difference measures were also treated as independent variables. There were two levels of IQ, high (mean IQ of 121) and low (mean IQ of 107), and two levels of learning rate. The latter measure was obtained as time-to-complete pre-experimental self-paced instructional programs of relevance to the experimental materials, and was categorized as fast (mean time of 25 minutes) and slow (mean time of 31 minutes). This resulted in a 3x2x2 design, or one containing 12 conditions. Analyses of variance applied to each of these pre-experimental differences in levels revealed highly significant differences beyond the .01 level of confidence.

Dependent variables. The primary dependent variable was the subject's score on an achievement test. The test consisted of retention items covering material presented in the original lesson; and transfer items covering the same concepts and principles presented in original learning, but using new applications. The test is reproduced in its entirety in Appendix B, page 8.

Experimental Procedure

All subjects received identical pre-experimental treatment designed to provide a common background and level of prior knowledge (relevant to "mechanical advantage," the topic covered in the experiment). All students observed the following general schedule (with minor variations in the time of administration of self-instructional programs in the schools, occasioned by ongoing schedule requirements):

Week 1 - Pre-Experimental Learning

Day 1
- pretest on "mechanical advantage"
- program on "how to go through a program"

Day 2 program on "force and motion"

Day 3 general introduction to "levers"

Week 3 - Original Learning

A fixed-paced, programmed visual lesson on film and self-paced verbal lesson on "mechanical advantage" in booklets. Following this, students were assigned at random to different experimental treatments as follows:

Week 5 - Review Session

Group A: Repeat of original fixed-paced visual lesson on film.

Group B: A new, fixed-paced visual lesson on film containing novel examples.

Group C: Control group, having no review.

Week 9 - Achievement Test of Retention and Transfer

The same test given to all groups.

Experimental Materials

All experimental materials are reproduced in Appendices A and B, save for the visual lesson, which was described in some detail in the report of the first study in this series, presented earlier in this report.

All verbal programs administered in the classroom as well as the verbal program segments serially intermixed with the original visual lesson were those used in Study No. 1. Briefly, it may be pointed out their purpose was to attempt to bring all students up to a common level of prior knowledge concerning levers and the concepts of force, length, balance, etc. related to them. These programs were prepared in the REP style of programming developed by Gropper (1965b). The visual program was also developed for use in Study No. 1. It was administered to all students in their original learning session.

In the experimental portion of this study, a new visual presentation was prepared for use as a review lesson. Each segment of this lesson covered the same concepts and principles as the original, but used novel examples not encountered in the original lesson. Whereas a straight board (a lever) was used consistently throughout the original lesson, other examples of machines (pulley), of levers (screwdriver, crowbar, hammer, tongs), and of loads (lid of can, nail, etc.) were used in the review material. Like the original visual lesson, the novel one was programmed. It required discrimination practice (pictorial response options) involving the visual events of the lesson, and provided for responding on the basis of pictorial options. A full description of this instructional method is included in the report of Study No. 1.

Subjects

The learners were eighth-grade students drawn from five classes in the public and Diocesan schools of Pittsburgh. These subjects were assigned at random to the three experimental conditions. A total of 72 subjects (24 for each condition) was used in the analysis of results. An analysis of variance indicated no significant differences among these treatment groups with respect to IQ measured before the experiment ($F = 0.99$; df 2 and 60; $P > .05$).

RESULTS

Pretest on Mechanical Advantage

Scores obtained on the pretest dealing with mechanical advantage showed clear differences between the means of the high-IQ and low-IQ groups, as might be expected. The means were 5.86 and 3.22 (S.D. = 2.77, 1.66), respectively, and a significant difference was indicated by an F of 23.8, df 1 and 60, $P < .01$. Tests applied to the three different treatment groups, however, indicated no significant differences between them on the pretest ($F = 2.43$, df 2 and 60, $P > .05$). Thus the groups subjected to different experimental treatments were comparable to begin with, as indicated by pretest scores.

Scores on Retention Test

Scores on the test of retention permit a comparison of performance of the three groups given different experimental treatments. The maximum possible score was 14. The mean retention score for the group which used the original lesson for review was 7.46 (S.D. = 3.89); for the group having a lesson containing new examples in review, 7.04 (S.D. = 3.30); and for the (control) group having no review, 5.25 (S.D. = 2.92). The relevant F measure is 4.79, df 2 and 60, $P < .05$. A t-test applied to the difference between each of the two experimental groups and the control group indicated both of these differences to be significant ones ($t = 1.99, 2.12$; $P < .05$). The difference between the two experimental treatments, however, was not significant. These results may therefore be said to indicate no difference between the original lesson *vs*. the new lesson as review procedures. The only difference, and that a substantial one, is between review and no review.

Intelligence (IQ), however, shows up in this comparison of retention scores with a considerable effect. The mean scores on the retention test for the high-IQ group were 8.75 (S.D. = 3.30), and for the low-IQ group, 4.41 (S.D. = 2.02). This difference is a significant one ($F = 48.99$, df 1 and 60, $P < .01$).

A test of significance was also made in retention scores for subjects exhibiting high *vs*. low learning rates, as measured by time to complete pre-experimental self-paced programs. Although the means differed slightly (7.0 and 6.1 respectively), the difference was not a significant one (F = 1.81, df 1 and 60, $P > .05$).

Scores on Test of Transfer

Similar results were obtained by comparison of the scores indicating transfer of learning in the various groups. The transfer test had a maximum score of 19. The mean transfer score for the group using the original lesson in review was 8.58 (S.D. = 4.24); for the group using the "novel example" lesson, 6.96 (S.D. = 3.71); and for the group having no review, 5.54 (S.D. = 3.40). The F-test yielded values of F = 5.40; df 2 and 60; $P < .01$, in this comparison. A t-test applied to the individual means showed none of the pairs of differences to be significant except that between review by means of the original lesson and no review (t = 2.74, $P < .01$). The review by means of a lesson containing new visual examples did not enhance the amount of transfer over that occurring in the condition having no review.

IQ levels in this case also have a marked relation to the scores obtained on the transfer test. The means were 8.91 (S.D. = 4.18) and 5.13 (S.D. = 2.60) respectively for high and low IQ groups (F = 24.94, df 1 and 60, $P < .01$).

No significant relation was found between transfer scores and measures of rate of learning obtained from administration of the pre-experimental self-paced programs. The value of F in this case was 0.44, df 1 and 60, $P > .05$.

DISCUSSION

The first hypothesis of interest in the study is that review sessions requiring application of learned principles to pictorially presented examples on mechanical advantage improves both retention and transfer. This question was explored both with respect to retention of the principles six weeks following the original learning, and also with respect to transfer of learning to problems having a somewhat novel content, following the same interval. Other corollary issues were to be investigated, including the relation of retention and transfer scores to IQ, and to a measure of learning rate obtained from pre-experimental learning programs.

With respect to the first hypothesis, the results of the study are fairly clear-cut. An advantage in final achievement has been shown in both retention and transfer scores of a review session interposed during the second week of the interval of six weeks following the completion of learning. Scores on both retention and transfer tests were found to be significantly superior in groups having the pictorially presented review, as compared with those of a group having no review.

The second major hypothesis under investigation was that effectiveness of review would be enhanced by the use of novel visual examples in the review lesson, as compared with a review lesson covering the same principles, but containing the same visual examples used in original learning. Regarding this question, it was found that the review containing the visual examples of the original lesson did not differ significantly in effectiveness for retention from the form containing novel examples. For transfer of learning, a significant difference was not found favoring the review with novel visual examples over no review; whereas the form containing "old" visual examples was significantly superior to the condition with no review.

We are thus confronted with the not surprising finding that review in the sense of "going over the same material" after an interval of time has a definite heightening effect upon retention. This is, of course, reminiscent of results with other materials like lists of verbal associates (cf. Underwood, 1964, p. 148). It appears likewise to be true for transfer of learning of verbal associates, that overlearning has a marked tendency to increase the amount of transfer (Mandler, 1954; Mandler & Heinemann, 1956). While the question of generalizability of findings from verbal learning to the learning of principles can reasonably be raised, nevertheless the facts would seem to indicate that review is effective in both kinds of learning.

The present findings regarding the relative ineffectiveness of novel examples in enhancing the transfer of training measured some weeks following learning may in some measure be related to an ineffectiveness of the examples employed during review in effecting the necessary generalization. The examples were, after all, physically quite dissimilar from those used during learning. Perhaps they made it difficult for the learner to abstract the essential conceptual features. Otherwise, the finding that novel examples did not significantly improve review may be related to some important theoretical conceptions. Since studies have shown varied examples in original learning to have an important influence on transfer (cf. Duncan, 1958), the results reported here suggest a marked difference in the effect of this kind of variable on the retaining of knowledge for later application (transfer). In other words, a review session, in contrast with original learning, may not be capable of facilitating transfer; perhaps all one can influence by means of review is retention. When transfer is tested at a time following review, its limits may be set by what can be retained. The suggestion is, one can "teach for transfer" in original learning, but possibly one cannot "review for transfer." The effects of review are primarily upon retention, and this study has revealed no better form for the review than that of the material used for original learning. The results provide no hint of qualities in novel visual examples which would make them peculiarly useful in review as a means of enhancing transfer.

The results provide added evidence, if any is needed, that differences in IQ influence amount of retention and amount of transfer of learning to a significant degree. The idea is reaffirmed that measures of IQ are related to several different kinds of activities of practical importance to the learning of school-relevant materials, and that among these activities are the capabilities of retaining and of generalizing (i.e., transferring) what has been learned. It is also of interest to note the insignificant relationships obtained in this study with the variable of learning rate, as measured for individuals in a pre-experimental session using a verbal self-paced constructional program. Rate of learning has revealed itself in previous studies (Gropper & Kress, 1965) as a variable of considerable importance in its relation to achievement under self-paced conditions. In the first study of this present series, rate of learning exhibited some of the most important differences in correlation with aptitudes, particularly when verbal presentation of materials was employed. Yet correlations of learning rate with retention scores, under each condition, were uniformly low in that study. Similar results are found in the present experiment: a measure of learning rate obtained with pre-experimental materials is revealed to be insignificantly related to either retention or transfer scores, under all three conditions of review. Although learning rate may be moderately related to achievement scores on the same materials, the present results show time to learn one set of materials to be not a good predictor of either retention or transfer of training measures on other materials.

The general implications of these results, so far as visual demonstrations are concerned, are that pictorial presentations can be of considerable usefulness in enhancing both retention and transfer. But so far as the present findings are able to throw light upon the reasons for this utility, it does not appear to arise from the employment of novel pictorial examples. Of course, this does not mean that a peculiar effectiveness of novel examples in reviews may not be found in future research. A more precisely defined set of learning and retention conditions may be necessary to reveal such effects.

REFERENCES

Anastasi, A. Psychological testing. (2nd Edition) New York: Macillan, 1961.

Carpenter, C. R. A theoretical orientation for instructional film research. Audio-Visual Communication Review, 1953, 1, 38-52.

Carpenter, C. R. Approaches to promising areas of research in the field of instructional television. In, New teaching aids for the American classroom. Stanford: The Institute for Communication Research, 1960. Pp. 73-94.

Cronbach, L. J. & Gleser, G. C. Psychological tests and personnel decisions. (2nd Edition) Urbana: University of Illinois Press, 1965.

Duncan, C. P. Transfer after training with single versus multiple tasks. Journal of Experimental Psychology, 1958, 55, 63-72.

Galton, F. Inquiries into human faculty and its development. (2nd Edition) New York: Dutton, 1907.

Gibson, J. J. (Ed.) Motion picture testing and research. Washington, D. C.: Superintendent of Public Documents, Government Printing Office, 1947. (Army Air Forces Report No. 7)

Gropper, G. L. Why is a picture worth a thousand words? Audiovisual Communication Review, 1963, 11, 75-95.

Gropper, G. L. Controlling student responses during visual presentations - Report #2. Studies in televised instruction: The role of visuals in verbal learning. Study No. 1 - An investigation of response control during visual presentations. Study No. 2 - Integrating visual and verbal presentations. Pittsburgh: American Institutes for Research, October 1965. (a)

Gropper, G. L. A description of the REP style program and its rationale. Presented at the NSPI convention held in Philadephia, Pennsylvania, 1965. (b)

Gropper, G. L. & Kress, G. C., Jr. Individualizing instruction through pacing procedures. Audiovisual Communication Review, 1965, 13, 165-182.

Guilford, J. P. The structure of intellect. Psychological Bulletin, 1956, 53, 267-293.

Hoban, C. F. The usable residue of educational film research. In, New teaching aids for the American classroom. Stanford: Stanford University, The Institute for Communication Research, 1960. Pp. 95-115.

Hoban, C. F., Jr. & van Ormer, E. B. Instructional film research 1918-1950. University Park, Pennsylvania: The Pennsylvania State University, December, 1950. (Technical Report No. SDC 269-7-19) (ASTIA Doc. No. 178305)

Kanner, J. H. Runyon, R. P., & Desiderato, O. Television in army training: Evaluation of television in army basic training. Washington, D. C.: Human Resources Research Office, George Washington University, 1954. (Technical Report HumRRO 14)

Kress, G. C., Jr. & Gropper, G. L. Individual differences in learning from self-paced programmed instruction - Report #1. Studies in televised instruction: Individualizing group instruction. Pittsburgh: American Institutes for Research, 1964.

McGeoch, J. A. & Irion, A. L. The psychology of human learning. (2nd Edition) New York: Longmans, 1952.

Mandler, G. Transfer of training as a function of degree of response overlearning. Journal of Experimental Psychology, 1954, 47, 411-417.

Mandler, G. & Heinemann, S. Effect of overlearning of a verbal response on transfer of training. Journal of Experimental Psychology, 1956, 52 39-46.

Rulon, P. J. The sound motion picture in science teaching. Cambridge: Harvard University Press, 1933. 1-236 (Harvard Studies in Education, Vol. 20)

Schramm, W. What we know about learning from instructional television. In, Educational television - The next ten years. Stanford, California: Stanford University, The Institute for Communication Research, 1962. Pp. 52-76.

Travers, R. M. W. An inquiry into the problem of predicting achievement. Lackland AFB, Texas: Air Force Personnel and Training Research Center, 1954. (AFPTRC-TR-54-93).

Underwood, B. J. Laboratory studies of verbal learning. In E. R. Hilgard (Ed.), Theories of learning and instruction. Chicago: National Society for the Study of Education, 1964. Pp. 133-152.

Vernon, P. E. An experiment on the value of the film and film-strip in instruction of adults. British Journal of Educational Psychology, 1946, 16, 149-162.

APPENDIX A

Programmed Materials and Tests

Study #1

Page No.

1. Lever Program A-1
2. Visual Answer Booklet A-27
3. Levers - Verbal Version A-32
4. Achievement Test A-44
5. Correlational Matrixes A-56

Studies #1 & #2

LEVERS*

1.

In order to lift a 100-lb. load by hand, the force you have to apply to the load is

less than 100 lbs.	100 lbs.
	X

In order to lift the same load with a lever, the lever force

can be less than 100 lbs.	has to be 100 lbs.	has to be more than 100 lbs.
	X	

2.

In order to lift a 35-lb. object, the force needed to lift the object is 35 lbs.

when it is lifted either by hand or by a lever	only when you lift it by hand	only when the lifting end of a lever lifts it
X		

3.

The force needed to lift any object must be equal to the weight of the object

no matter how you lift it	only when you lift it by hand	only when you lift it with a lever
X		

4.

In order to raise a 48-lb. rock with a lever, the lever force

can be less than 48 lbs.	has to be 48 lbs.	has to be very much more than 48 lbs.
	X	

5.

In order to raise any load with a lever, the lever force

can be less than the weight of the load	has to be equal to the weight of the load	has to be very much more than the weight of the load
	X	

6.

EDIT THIS SENTENCE

You need to apply at least a 1-lb. force to lift a 2-lb. book.

If the underlined part of the sentence is correct, COPY the underlined words.

____

If the underlined part of the sentence is incorrect, CHANGE the underlined words.

2-LB. FORCE

---

*The frames reproduced here are those which were presented to the subjects as confirmation frames after they had made their own responses. X's are used to indicate the correct multiple choice responses.

7.

EDIT THIS SENTENCE

The force the lever must apply to the load can be less than the weight of the load.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

MUST BE EQUAL TO

8.

A man wants to lift a load with a lever. You want to tell him how much lever force the lever will have to apply to the load in order to lift it.

What would you tell him?

THE LEVER FORCE MUST BE AS MUCH AS (EQUAL TO) THE WEIGHT OF THE LOAD.

9.

If you lifted a 30-lb. box with a lever, the LEVER FORCE which lifts the box would have to be 30 lbs.

Therefore, the force which is equal to the weight of the load is the

pushing down effort force	lifting lever force
	X

10.

EDIT THIS SENTENCE

The force which has to be equal to the weight of the load is the effort force.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

LEVER FORCE

11.

The boy couldn't lift the load with the lever because the lever force was

less than the weight of the load	more than the weight of the load
X	

12.

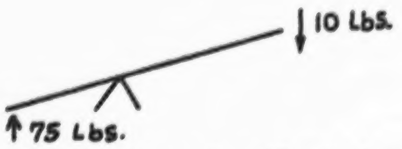
Construct a sentence out of these words (and any other words you need).

lift a load with a lever

less than the weight of the load

YOU CAN'T LIFT A LOAD WITH A LEVER IF THE LEVER FORCE IS LESS THAN THE WEIGHT OF THE LOAD.

13.



Compare the size of effort force and the lever force.

The effort force is

the same as the lever force	smaller than the lever force	larger than the lever force
	X	

We can get a lever force of 75 lbs. at the lifting end and lift a 75-lb. load even though the effort force at the other end is

less than 75 lbs.	equal to 75 lbs.	more than 75 lbs.
X		

14.

A lever helps you to lift heavy things. The effort force applied by you at the pushing down end of the lever is therefore usually

smaller than the lever force	larger than the lever force
____	____
X	____

15.

The lever force which lifts the load is always equal to the weight of the load.

But the effort force you apply at the other end is

less than the lever force and less than the weight of the load	more than the lever force and more than the weight of the load
____	____
X	____

16.

Here is the main reason for using levers: They help you to lift heavy loads.

This means that the effort force you apply at the pushing down end is

less than the weight of the load	more than the weight of the load
____	____
X	____

17.

You use a lever to lift a 100-lb. load. The lifting end of the lever has to apply a lever force of 100 lbs. to the load.

The effort force you apply to the pushing down end of the lever

can be less than 100 lbs.	has to be equal to 100 lbs.	has to be more than 100 lbs.
____	____	____
X	____	____

18.

Which is usually bigger?

the effort force	the lever force
____	____
____	X

19.

EDIT THIS SENTENCE

The effort force is usually larger than the lever force.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

SMALLER THAN

20.

Construct a sentence out of these words.

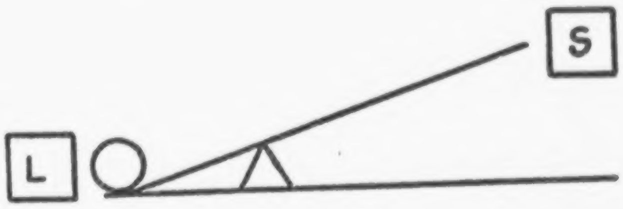
smaller than lever force effort force	THE EFFORT FORCE IS USUALLY SMALLER THAN THE LEVER FORCE.

21.

Remember that L stands for Load, Lever force, and Large.

Put an L next to the place where a large force is applied.

Put an S next to the place where a small force is applied.



22.

Construct a sentence out of these words.

lift a 100-lb. load

the lever force has to be

but the effort force

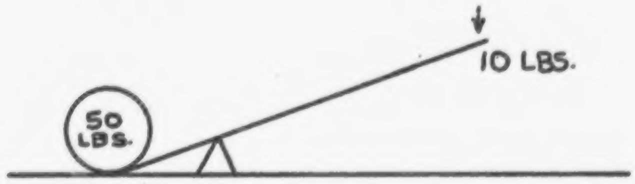
IN ORDER TO LIFT A 100-LB. LOAD THE LEVER FORCE HAS TO BE 100 LBS., BUT THE EFFORT FORCE CAN BE LESS THAN 100 LBS.

23.

You apply a 10-lb. force at one end and at the other end out comes a 50-lb. force.

This means that

the force was changed and made bigger	the force was not changed
X	



24.

The reason you can lift a 50-lb. object, even though you apply only a small 10-lb. effort force to a lever is that

the lever takes your 10-lb. effort force and turns it into a a 50-lb. lever force	the lever doesn't do anything to your effort force
X	

25.

To lift a 35-lb. load, you apply a 5-lb. downward effort force at one end of the lever.

The lever force which comes out the other end and lifts the load up is 35 lbs.

The effort force was changed and made smaller.	The effort force was changed and made bigger.
	X

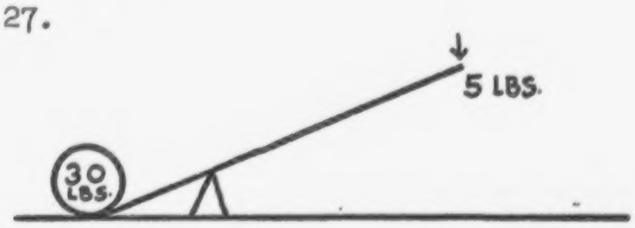
26.

You start by applying a 10-lb. effort force at one end of a lever.

The lever force which comes out at the other end is 60 lbs.

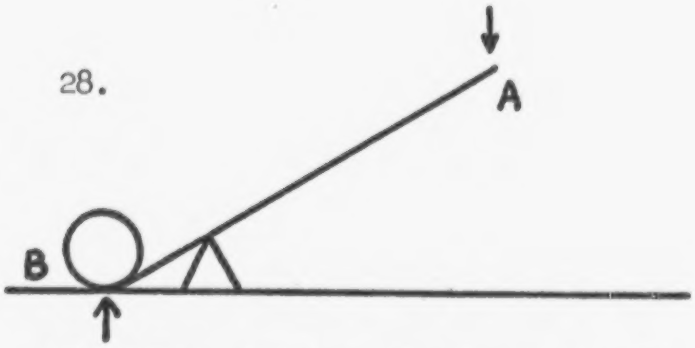
The lever changed a 10-lb. force into a 60-lb. force.	The lever changed a 60-lb. force into a 10-lb. force.
X	

27.



The lever changed the 5-lb. effort force into a 30-lb. lever force.	The lever changed the 30-lb. lever force into a 5-lb. effort force.
X	

28.



The force at A is changed into a bigger force at B.	The force at B is changed into a smaller force at A.
X	

29.

You start with a small effort force and out comes a large lever force.	You start with a large lever force and out comes a small effort force.
X	

30.

The reason we use levers is that the lever takes our effort force and produces a lever force at the other end which is

smaller than the effort force	bigger than the effort force
	X

Therefore, this means that even if we only apply a small effort force the lever can lift

small loads	large loads
	X

31.

We only apply a small effort force to a lever, but the lifting end can still lift a large load because levers take small effort forces and change them into

small lever forces	large lever forces
	X

32.

We can produce a large lever force and lift a large load at the lifting end even if we only apply a small effort force at the pushing down end, because the lever

takes a small effort force and turns it into a large lever force	doesn't change the effort force at all
X	

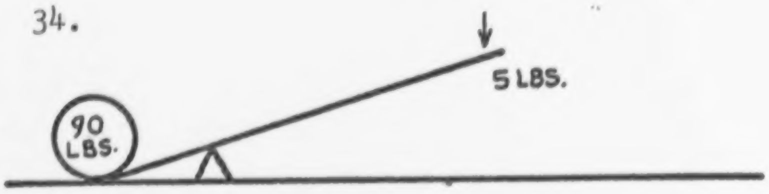
33.

A lever applies a large lever force to a load, even though you only apply a small effort force to the lever.

This is possible because the lever

changes your small effort force into a big lever force	doesn't change anything
X	

34.



By applying an effort force of only 5 lbs. to the lever, we lift a 90-lb. load. The reason why this is possible is that

EDIT THIS SENTENCE

the lever takes a small effort force of 5 lbs. and turns it into a small lever force of 90 lbs.

If the underlined part is correct, COPY the underlined word.

If the underlined part is incorrect, CHANGE the underlined word.

LARGE

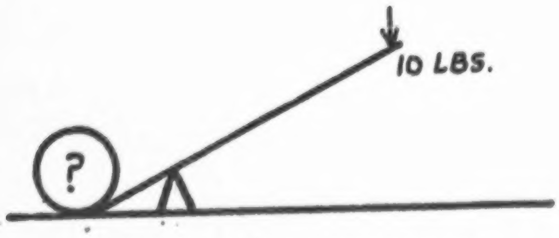
35.

Construct a sentence out of these words.

most levers
small effort force
large lever force

MOST LEVERS TAKE A SMALL EFFORT FORCE AND TURN IT INTO A LARGE LEVER FORCE.

36.



EDIT THIS SENTENCE

With this lever you can only lift loads which weigh 10 lbs.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

LIFT LOADS WHICH WEIGH MORE THAN 10 LBS.

37.

Construct a sentence out of these words.

lift a heavy load
small effort force
because a lever

WE CAN LIFT A HEAVY LOAD WITH A SMALL EFFORT FORCE BECAUSE A LEVER TURNS A SMALL EFFORT FORCE INTO A LARGE LEVER FORCE.

38.

When you lift a 100-lb. load by hand, how much force do you have to apply to the load? 100 LBS.

When the load is lifted by a lever, how big must the lifting lever force be? 100 LBS.

The effort force you apply to the lever can be LESS than this because THE LEVER WILL TAKE THE EFFORT FORCE AND MAKE IT BIGGER.

39.

When a force is increased 2 times, it becomes

2 times bigger than before	5 times bigger than before
X	

When a force is increased 3 times, it becomes

3 times bigger than before	1/3 as big as before
X	

40.

A force will become 4 times bigger than before when it is increased

2 times	4 times	8 times
	X	

A force will become 8 times bigger when it is increased

2 times	4 times	8 times
		X

41.

A 20-lb. force is increased 4 times.

It becomes

a 5-lb. force	an 80-lb. force
	X

If a 20-lb. force is increased 5 times, it becomes

a 5-lb. force	a 20-lb. force	a 100-lb. force
		X

42.

A 10-lb. force is changed into a 30-lb. force.

EDIT THIS SENTENCE

The force has been increased 30 times.

If the underlined part is correct, COPY the underlined words.

If the underlined part is incorrect, CHANGE the underlined words.

3 TIMES

43.

A 5-lb. force which is increased 8 times will become a 40-LB. FORCE.

44.

A 10-lb. effort force which is turned into a 50-lb. lever force at the other end of the lever has been made

5 times bigger	10 times bigger	50 times bigger
X		

A 10-lb. effort force which is turned into a 100-lb. lever force has been made

10 times bigger	100 times bigger
X	

45.

Construct a sentence out of these words.

a 10-lb. effort force
7 times
a 70-lb. lever force

A 10-LB. EFFORT FORCE THAT IS INCREASED 7 TIMES WILL BECOME A 70-LB. LEVER FORCE.

46.

A lever changed a 5-lb. effort force applied at one end of a lever into a 25-lb. lever force at the other end.

EDIT THIS SENTENCE

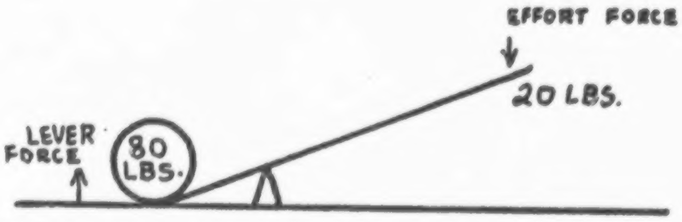
The effort force was made 25 times bigger.

If the underlined part is correct, COPY the underlined words.

If the underlined part is incorrect, CHANGE the underlined words.

5 TIMES BIGGER

47.



The effort force was increased from 20 lbs. to a lever force of 80 lbs.

The effort force has been increased 4 times

If the effort force had been increased 5 times, the lever force would be 100 lbs.

48.

An effort force of 50 is increased 3 times by a lever when it produces at the other end

a lever force of 100 lbs.	a lever force of 150 lbs.	a lever force of 200 lbs.
	X	

49.

Lever force: 80 lbs.
Effort force: 20 lbs.

We can lift a load of 80 lbs. at one end of a lever by applying an effort force at the other end of only 20 lbs.

We can do this because the lever

increases the effort force 4 times and produces a lever force of 80 lbs.	decreases the effort force 4 times and produces a lever force of 5 lbs.
X	

50.

The help a lever gives us in changing a small effort force into a big lever force is called mechanical advantage.

We can lift heavy loads with levers because of their MECHANICAL ADVANTAGE.

51.

A lever has a mechanical advantage of 5 when the lever

increases the effort force 5 times	decreases the effort force 5 times
X	

When this happens, the lever produces a lever force at the other end which is

5 times bigger than the effort force	5 times smaller than the effort force
X	

52.

A lever has a mechanical advantage of 7 when it

increases the effort force 7 times	decreases the effort force 7 times
X	

When this happens, the lever produces a lever force at the other end which is

7 times smaller than the effort force	7 times bigger than the effort force
	X

53.

A lever has a mechanical advantage of 4. This means that the lever will increase the effort force

less than 4 times	exactly 4 times	more than 4 times
	X	

Therefore, the effort force you apply at one end of the lever will be changed at the other end into a lever force.

The lever force will be

4 times smaller than the effort force	4 times bigger than the effort force
	X

If the effort force was 20 lbs., the lever force will be

20 lbs.	80 lbs.
	X

54.

We use levers because they have a mechanical advantage.

This means the lever

takes our small effort force and turns it into a big lever force	takes our large effort force and turns it into a small lever force
X	

55.

Lever A has a mechanical advantage of 3.

Lever B has a mechanical advantage of 7.

Lever B will increase an effort more times because it has

less mechanical advantage	more mechanical advantage
	X

56.

The more mechanical advantage a lever has

the fewer times it will increase the effort force	the more times it will increase the effort force
	X

57.

EDIT THIS SENTENCE

The mechanical advantage of a lever tells us how many times an effort force is increased.

If the underlined part is correct, COPY the underlined words.

HOW MANY TIMES AN EFFORT FORCE IS INCREASED

If the underlined part is incorrect, CHANGE the underlined words.

________________________.

58.

Construct a sentence out of these words.

lever mechanical advantage of 6 effort force increased	IF A LEVER HAS A MECHANICAL ADVANTAGE OF 6, THE EFFORT FORCE WILL BE INCREASED 6 TIMES.

59.

The amount of mechanical advantage a lever has tells us HOW MANY TIMES AN EFFORT FORCE IS INCREASED.

60.

A load of 900 lbs. can be raised by applying an effort force of only 30 lbs. at the pushing down end of the lever, because levers

decrease effort forces	have mechanical advantage	decrease loads
	X	

This means that the lever takes the small effort force of 30 lbs. and

increases it into a large lever force of 900 lbs.	doesn't change at all
X	

61.

EDIT THIS SENTENCE

Because a lever has mechanical advantage, you can lift a 250-lb. load by applying an effort force of more than 250 lbs. to the lever.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

LESS THAN 250 LBS.

62.

Construct a sentence out of these words.

mechanical advantage heavy loads effort force	WE CAN LIFT HEAVY LOADS WITH A SMALL EFFORT FORCE BECAUSE LEVERS HAVE MECHANICAL ADVANTAGE.

63.

We use levers because they have mechanical advantage.

What does the mechanical advantage of a lever let us do?
IT LETS US APPLY A SMALL EFFORT FORCE TO THE LEVER AND RAISE A HEAVY LOAD.

The reason this happens is that, when a lever has mechanical advantage, it takes a small effort force and INCREASES IT OR MAKES IT BIGGER.

64.

If we didn't have a lever and applied a small force directly to a heavy load, the load would not be lifted.

Why can we lift a heavy load with a small effort force when we do use a lever?

BECAUSE THE LEVER HAS MECHANICAL ADVANTAGE AND TURNS A SMALL EFFORT FORCE INTO A BIG LEVER FORCE.

65.

A lever has a mechanical advantage of 4. You apply an effort force of 10 lbs.

The lever force will be

4 lbs.	10 lbs.	40 lbs.
		X

66.

Lever A has a mechanical advantage of 3. This means that the effort force is multiplied by

0	3	9
	X	

An effort force of 5 lbs. applied to Lever A will produce a lever force of

3 lbs.	5 lbs.	15 lbs.
		X

You can find out what the lever force will be by

multiplying effort force x mechanical advantage	multiplying lever force x mechanical advantage
X	

67.

The formula for finding out how big the lever force will be is

EDIT THIS SENTENCE

effort force x mechanical advantage = lever force.

If the formula is correct, COPY the underlined words.

EFFORT FORCE X MECHANICAL ADVANTAGE = LEVER FORCE.

If the formula is incorrect, CHANGE the underlined words.

68.

Effort force
Lever force
Mechanical advantage

Write out the formula for finding out how big the lever force will be.

EFFORT FORCE X MECHANICAL ADVANTAGE = LEVER FORCE

69.

Now we can use the formula to solve this problem.

Effort force = 12 lbs.
Mechanical advantage = 3

What will the lever force be?

The lever force will be 3 x 12 = 36 lbs.

70.

Effort force x mechanical advantage = lever force.

If we know what the effort force and mechanical advantage are, we can figure out the LEVER FORCE.

If we know what the effort force and the lever force are, we can figure out the MECHANICAL ADVANTAGE.

If we know what the mechanical advantage and lever force are, we can figure out the EFFORT FORCE.

71.

We can use the same formula to find out what the mechanical advantage of a lever is.

effort force x mechanical advantage = lever force

2 lbs. x ? = 14 lbs.

The mechanical advantage of this lever is

7	2	14
X		

72.

effort force x mechanical advantage = lever force

It takes an effort force of 10 lbs. to raise a 60-lb. load at the other end, if a lever has a mechanical advantage of

6	10	60
X		

73.

Effort force = 10 lbs.
Lever force = 30 lbs.

effort force x mechanical advantage = lever force

The mechanical advantage of this lever is

3	10	30
X		

74.

effort force x mechanical advantage = lever force

Lever force = 20 lbs.
Effort force = 4 lbs.

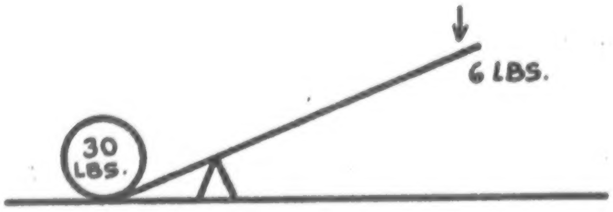
What is the mechanical advantage of this lever? 5

Therefore, what did the lever do to the effort force? INCREASED IT 5 TIMES.

75.

The formula which lets us figure out the lever force or the mechanical advantage is:

effort force x MECHANICAL ADVANTAGE = LEVER FORCE



What is the mechanical advantage of this lever? 5

76.

You want to lift a load weighing 80 lbs.
The lever has a mechanical advantage of 4.

effort force x mechanical advantage = lever force
? x 4 = 80 lbs.

You can lift the 80-lb. load by pushing the lever down with an effort force of

4 lbs.	20 lbs.	80 lbs.
	X	

77.

effort force x mechanical advantage = lever force

A lever has a mechanical advantage of 5.

You can lift a 500-lb. load by pushing the lever down with an effort force of

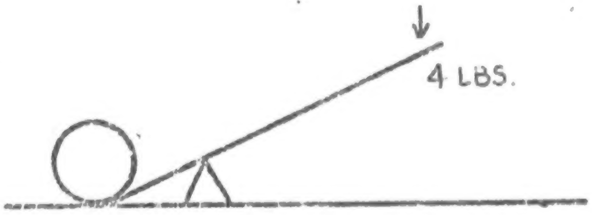
5 lbs.	100 lbs.	500 lbs.
	X	

78.

The formula for finding out how much effort force you will need is the same as for finding out mechanical advantage and lever force. Write it out here.

EFFORT FORCE X MECHANICAL ADVANTAGE = LEVER FORCE.

79.



Mechanical advantage of this lever is 7.

The lever will lift a load of 28 lbs.

80.

Use the formula to solve this problem.

Effort force = 10 lbs.
Mechanical advantage = 2

The lever force will be: 20 LBS.
You can lift a load weighing: 20 LBS.

81.

Lever force: 80 lbs.
Effort force: 10 lbs.

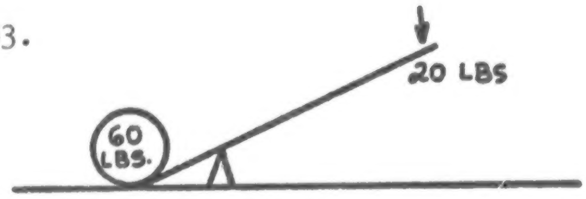
The mechanical advantage is: 8

82.

You need a lever force of: 30 lbs.
The mechanical advantage is: 3

You only need to apply an effort force of: 10 LBS.

83.



The mechanical advantage of this lever is 3.
This tells us that

EDIT THIS SENTENCE

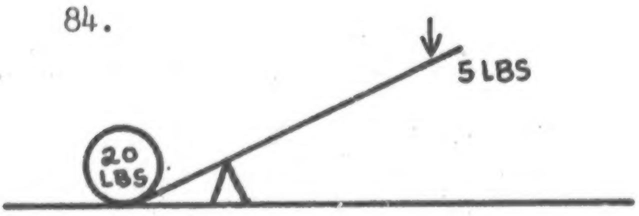
the effort force is increased 4 times, changing from 20 lbs. to 60 lbs.

If the underlined part is correct, COPY the underlined words.

If the underlined part is incorrect, CHANGE the underlined words.

INCREASED 3 TIMES

84.



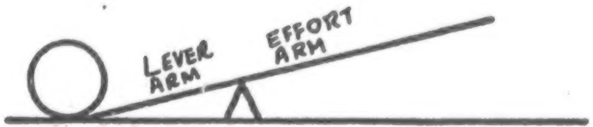
The mechanical advantage of this lever is 4.

Construct a sentence out of these words.

the effort
force was
times

THE EFFORT FORCE WAS INCREASED 4 TIMES.

85.



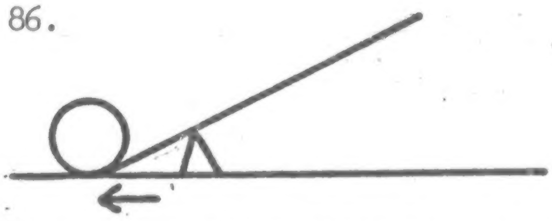
When the effort arm is made longer, the lever arm

gets shorter	gets longer
X	

When that happens, the fulcrum is

closer to the load	farther away from the load
X	

86.

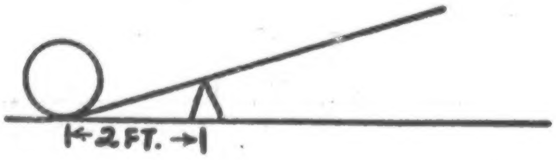


We can make the mechanical advantage of a lever bigger by placing the fulcrum closer to the load.

The closer the fulcrum is to the load

the less mechanical advantage a lever has	the more mechanical advantage a lever has
	X

87.



The fulcrum is 2 ft. away from the load.

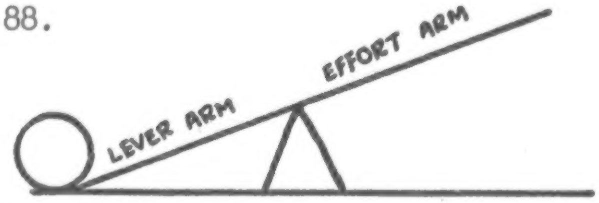
If the fulcrum is moved to only 1 ft. away from the load, the lever will have

less mechanical advantage	the same mechanical advantage	more mechanical advantage
		X

On the other hand, if the fulcrum moved farther away from the load, the lever will have

less mechanical advantage	the same mechanical advantage	more mechanical advantage
X		

88.



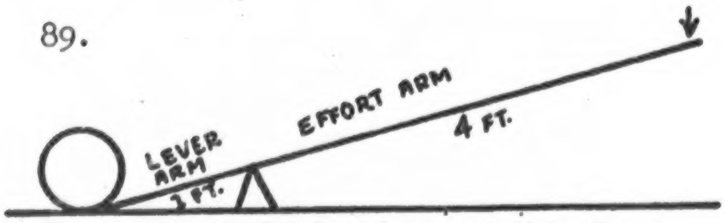
If we increase the length of the effort arm by moving the fulcrum closer to the load, the length of the lever arm becomes

smaller	larger
X	

When this happens the mechanical advantage of the lever will become

smaller	larger
	X

89.



The mechanical advantage of this lever is 4 since

the effort arm is 4 times longer than the lever arm	the lever arm is 4 times longer than the effort arm
X	

90.

Effort arm = 10 ft. long

Lever arm = 2 ft. long

The mechanical advantage of the lever is 5 since

the effort arm is 5 times longer than the lever arm	the lever arm is 5 times longer than the effort arm
X	

91.

Effort arm = 12

Lever arm = 2

The effort arm is 6 times longer than the lever arm.	The lever arm is 6 times longer than the effort arm.
X	

Therefore, the mechanical advantage of this lever is

2	6	12
	X	

92.

Effort arm = 12 ft. long

Lever arm = 6 ft. long

EDIT THIS SENTENCE

The mechanical advantage of this lever is 3 since the effort arm is 3 times longer than the lever arm.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

2 SINCE THE EFFORT ARM IS 2 TIMES LONGER (TWICE AS LONG) THAN THE LEVER ARM.

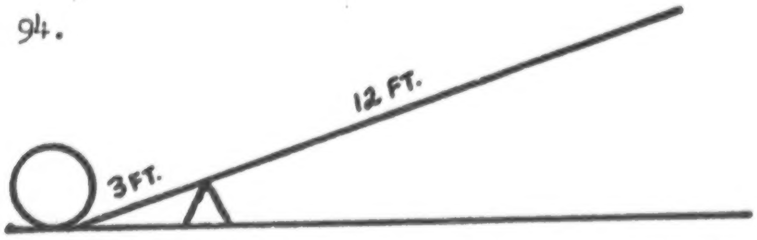
93.

Construct a sentence out of these words.

effort arm
5 times longer
lever arm
mechanical advantage

IF THE EFFORT ARM OF A LEVER IS 5 TIMES LONGER THAN THE LEVER ARM, THE MECHANICAL ADVANTAGE OF THAT LEVER WILL BE 5.

94.



The mechanical advantage of this lever is 4 because THE EFFORT ARM IS 4 TIMES LONGER THAN THE LEVER ARM.

95.

Lever A	Lever B
Effort arm is 5 times longer than the lever arm.	Effort arm is 7 times longer than the lever arm.

Lever C

Effort arm is
9 times longer
than the lever arm.

The mechanical advantage of these levers is

5 7 9

The lever with the smallest mechanical advantage is

A	B	C
X		

96.

Lever A	Lever B
Effort arm = 12 ft.	Effort arm = 12 ft.
Lever arm = 6 ft.	Lever arm = 2 ft.

The effort arm of Lever A is 2 times longer than its lever arm.

The effort arm of Lever B is 6 times longer than its lever arm.

Therefore, the lever with the larger mechanical advantage is

Lever A	Lever B
	X

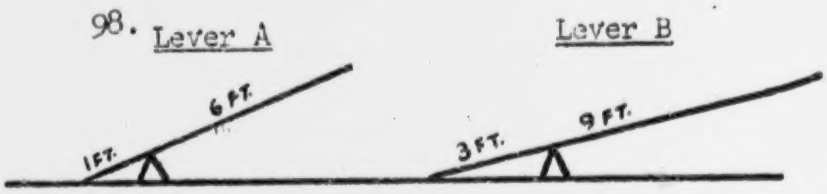
97.

	Lever A	Lever B	Lever C
Effort arm	20 ft.	20 ft.	20 ft.
Lever arm	4 ft.	5 ft.	10 ft.
Mechanical advantage	5	4	2

The lever with the least mechanical advantage is lever

A	B	C
		X

98.



Lever A has more mechanical advantage because its effort arm is 6 times longer than its lever arm, while in Lever B the effort arm is only 3 times longer than the lever arm.

EDIT THIS SENTENCE

The mechanical advantage of a lever depends on how many times longer the effort arm is than the lever arm.

If the underlined part is correct, COPY the underlined words.

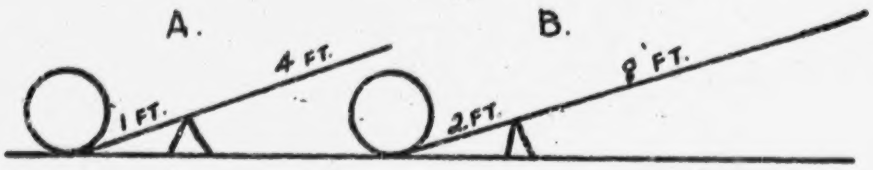
HOW MANY TIMES LONGER THE EFFORT ARM IS THAN THE LEVER ARM

If the underlined part is incorrect, CHANGE the underlined words.

99.

The mechanical advantage of a lever depends on HOW MUCH LONGER THE EFFORT ARM IS THAN THE LEVER ARM.

100.



Compare the mechanical advantage of Levers A and B.

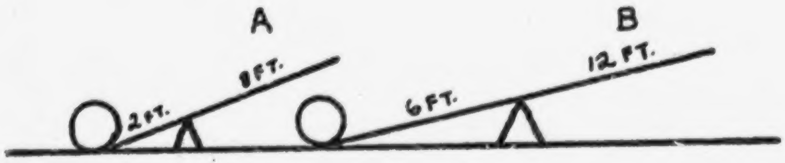
The mechanical advantage is

more for A	the same for both	more for B
	X	

The reason is that

Lever B is 10 ft. long and Lever A is only 5 ft. long	the effort arm is 4 times longer than the lever arm in both A and B
	X

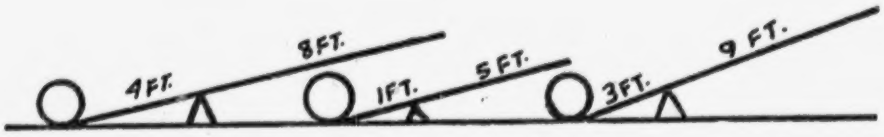
101.



Which lever has the bigger mechanical advantage?

A	B
X	

102.



The lever with the largest mechanical advantage is Lever B because THE EFFORT ARM IS 5 TIMES LONGER THAN THE LEVER ARM.

103.

The closeness of the fulcrum to the load determines how much mechanical advantage a lever has.

Therefore, a lever has more mechanical advantage when

the effort arm is longer than the lever arm	the effort arm is shorter than the lever arm
X	

104.

The effort arm of a lever was made a good deal longer than it was before,

EDIT THIS SENTENCE

therefore, the mechanical advantage decreased.

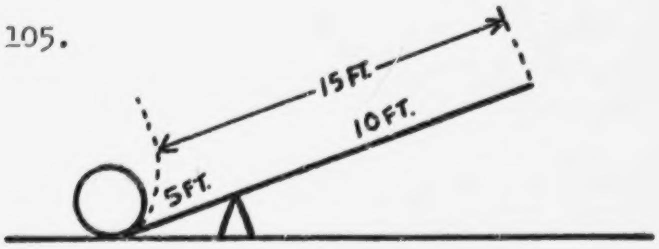
If the underlined part is correct, COPY the underlined word.

____

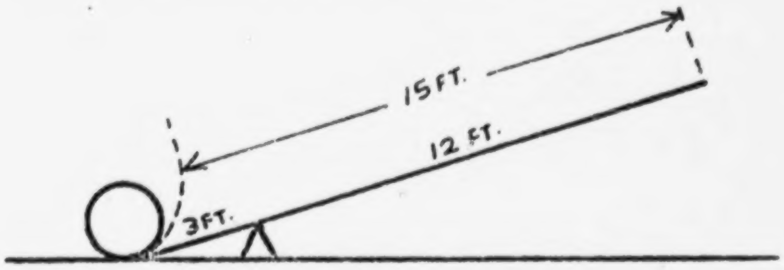
If the underlined part is incorrect, CHANGE the underlined word.

INCREASED

105.

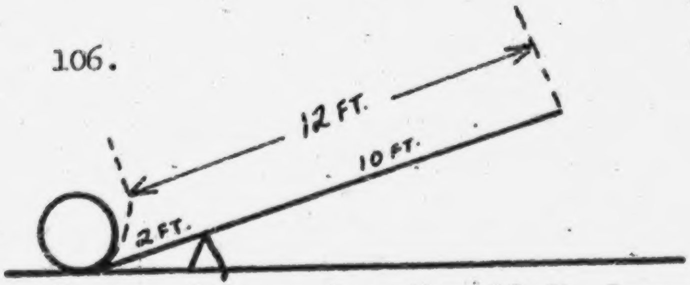


Below is another 15 ft. lever. Draw in the fulcrum so as to make the mechanical advantage of the lever larger than the one in the picture above. Put in numbers indicating how long the effort arm and how long the lever arm should be.

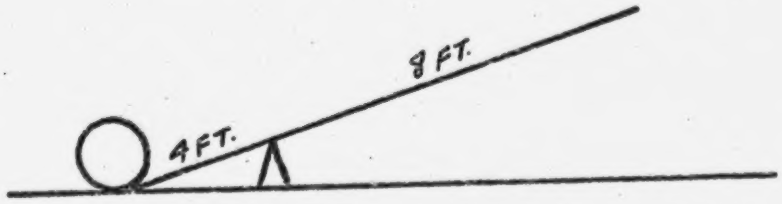


Other examples are correct if the lever arm is less than 5 ft.

106.



Draw a picture of another 12-ft. lever making the mechanical advantage smaller than this one. Put in numbers indicating how long the arms are.



Other examples are correct if the lever arm is longer than 2 ft.

107.

How much mechanical advantage a lever has depends on HOW MANY TIMES THE EFFORT ARM IS LONGER THAN THE LEVER ARM.

108.

Effort arm = 16 ft.

Lever arm = 2 ft.

The mechanical advantage of the lever is 8.

This means that an effort force of 10 lbs. will be increased to a lever force of 80 lbs.

109.

	A	B
Lever force	40 lbs.	50 lbs.
	↑	↑
Effort force	10 lbs.	10 lbs.

Which lever increased the effort force more times?

A	B
	X

That effort force was increased

from 10 lbs. to 40 lbs.	from 10 lbs. to 50 lbs.
	X

110.

	A	B	C
Lever force	10 lbs.	10 lbs.	10 lbs.
Effort force	1 lb.	3 lbs.	5 lbs.

Which lever increased the effort force the most number of times?

A	B	C
X		

111.

	A	B
Lever force	40 lbs.	100 lbs.
Effort force	10 lbs.	50 lbs.

The mechanical advantage of Lever A is 4.

The mechanical advantage of Lever B is 2.

The lever which has more mechanical a advantage is Lever A because

it increases the effort force more times	the lever force is bigger
X	

112.

	A	B	C
Lever force	10 lbs.	40 lbs.	300 lbs.
Effort force	2 lbs.	10 lbs.	100 lbs.

Which lever has the most mechanical advantage?

A	B	C
X		

The reason is that it

increases the effort force the most number of times	has the largest lever force
X	

113.

The lever with the largest mechanical advantage is

Lever force	40 lbs.	50 lbs.	60 lbs.
Effort force	10 lbs.	5 lbs.	20 lbs.
		X	

The reason is that it

increases the effort force the most number of times	has the largest lever force
X	

114.

The lever with the largest mechanical advantage is

1. lever force 40 lbs. effort force 10 lbs.	2. lever force 60 lbs. effort force 20 lbs.	3. lever force 100 lbs. effort force 50 lbs.
X		

The reason is that it

has the largest lever force	increases the effort force the least number of times	increases the effort force the most number of times
		X

115.

EDIT THIS SENTENCE

The lever which has the largest mechanical advantage is the one which increases the effort force the least number of times.

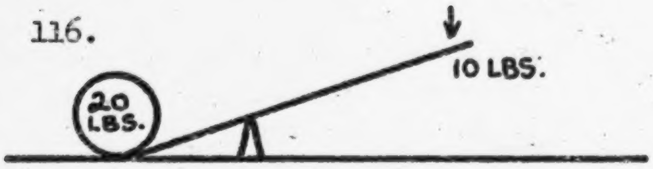
If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

INCREASES THE EFFORT FORCE THE MOST NUMBER OF TIMES

116.



EDIT THIS SENTENCE

The mechanical advantage of this lever is 2 because the effort force is increased 2 times.

If the underlined part is correct, COPY the underlined words.

THE MECHANICAL ADVANTAGE OF THIS LEVER IS 2 BECAUSE THE EFFORT FORCE IS INCREASED 2 TIMES.

If the underlined part is incorrect, CHANGE the underlined words.

______________________________.

117.

Lever force = 60
Effort force = 10

EDIT THIS SENTENCE

The mechanical advantage of this lever is 4, because the effort force is increased 4 times.

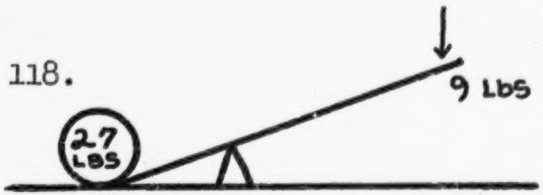
If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

6, BECAUSE THE EFFORT FORCE IS INCREASED 6 TIMES

118.

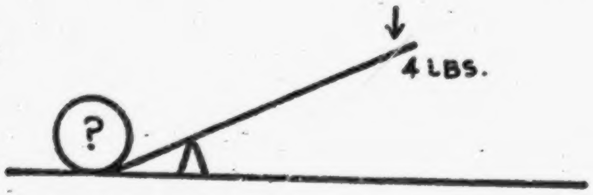


Construct a sentence out of these words about this picture.

the mechanical advantage
because the effort force
from 9 lbs. to

THE MECHANICAL ADVANTAGE OF THIS LEVER IS 3 BECAUSE THE EFFORT FORCE IS INCREASED FROM 9 LBS. TO 27 LBS.

119.



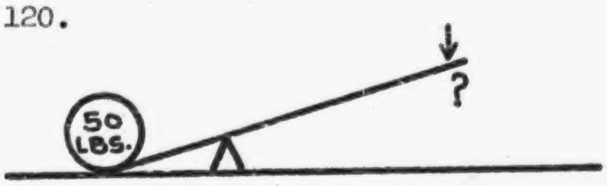
The mechanical advantage of this lever is 2.

This means the effort force will be increased 2 times.

The lever force therefore will be 8 lbs.

The lever can lift a load of 8 lbs.

120.



The mechanical advantage of this lever is 5.

The effort force can be 10 lbs. because the lever will increase the effort force from 10 lbs. to a lever force of 50 lbs.

The effort force was increased 5 times.

121.

EDIT THIS SENTENCE

The more times the effort force is increased, the more mechanical advantage a lever will have.

If the underlined part is correct, COPY the underlined words.

THE MORE TIMES THE EFFORT FORCE IS INCREASED

If the underlined part is incorrect, CHANGE the underlined words.

____

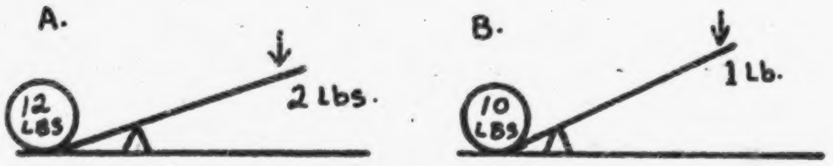
122.

Construct a sentence out of these words.

the fewer times
effort force
mechanical advantage

THE FEWER TIMES THE EFFORT FORCE IS INCREASED, THE LESS MECHANICAL ADVANTAGE A LEVER HAS.

123.



The lever with the larger mechanical advantage is Lever B because its effort force IS INCREASED 10 TIMES.

124.

When you know what the mechanical advantage of a lever is you know HOW MANY TIMES THE EFFORT FORCE IS INCREASED.

125.

You want to lift a 60-lb. load.

You can use the least effort force with the lever which has

the smallest mechanical advantage	the largest mechanical advantage
	X

The reason is, that lever will increase the effort force

the smallest number of times	the largest number of times
	X

126.

You want to lift a load. You have several levers to choose from.

The lever with the largest mechanical advantage will require the

smallest effort force	largest effort force
X	

127.

You can apply an effort force of 50 lbs. to several different levers.

The lever with the largest mechanical advantage is the one which will take your effort force and produce at the other end the

smallest lever force	largest lever force
	X

128.

A 150-lb. load has to be lifted.

The lever which has the smallest mechanical advantage in lifting the load is the one to which we have to apply

the smallest effort force	the largest effort force
	X

129.

	Lever A	Lever B	Lever C
Mechanical advantage:	5	10	20

The lever which will need the largest effort force is Lever

A	B	C
X		

Because it has

the smallest mechanical advantage	the largest mechanical advantage
X	

130.

A 40-lb. load has to be lifted.

	Lever A	Lever B	Lever C
Mechanical advantage:	10	8	2

Since it's easiest when you apply the least amount of effort force, you would choose Lever

A	B	C
X		

With that lever you would have to apply an effort force of only

4 lbs.	5 lbs.	20 lbs.
X		

131.

Any time you want to lift a load, you choose the lever which requires

the least effort force	the most effort force
X	

Therefore you will choose the lever which has the

least mechanical advantage	most mechanical advantage
	X

132.

We want to lift a heavy load.

EDIT THIS SENTENCE

If the mechanical advantage of a lever is large, we will have to apply a small effort force to the lever.

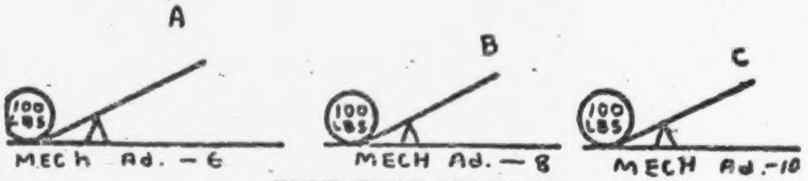
If the underlined part is correct, COPY the underlined words.

IF THE MECHANICAL ADVANTAGE OF A LEVER IS LARGE, WE WILL HAVE TO APPLY A SMALL EFFORT FORCE TO THE LEVER.

If the underlined part is incorrect, CHANGE the underlined words.

________________________________.

133.



EDIT THIS SENTENCE

The lever which will require the largest effort force is Lever C because it has the largest mechanical advantage.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

SMALLEST EFFORT FORCE

134.

Construct a sentence out of these words.

lever

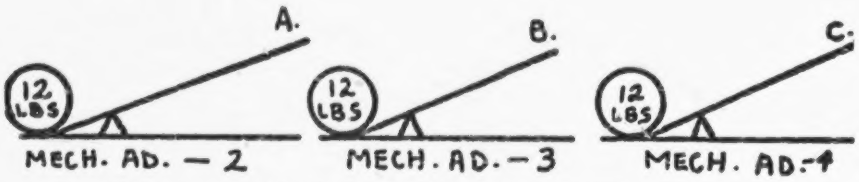
largest mechanical advantage

heavy load

effort force

THE LEVER WHICH HAS THE LARGEST MECHANICAL ADVANTAGE IS THE ONE WHICH CAN LIFT A HEAVY LOAD WITH THE SMALLEST EFFORT FORCE.

135.



If you wanted to lift the 12-lb. load, which of the three levers would you choose?
C

Why? (Use the words "mechanical advantage" and "effort force" in your answer.)

SINCE LEVER C HAS THE BIGGEST MECHANICAL ADVANTAGE, IT WILL REQUIRE THE SMALLEST EFFORT FORCE.

136.

	Lever A	Lever B	Lever C
Mechanical advantage:	4	6	9

An effort force of 10 lbs. can be applied to all three levers.

Lever C will lift the largest load even though the effort force applied to it is the same as the effort force applied to the rest.

The reason is that Lever C has

the smallest mechanical advantage	the largest mechanical advantage
______	______
______	X

137.

Even though you apply the same effort force to different levers, you can lift heavier loads with some of them because different levers have

the same mechanical advantage	different mechanical advantage
______	______
______	X

138.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	10 lbs.	10 lbs.
Mechanical advantage:	4	7	15
Load lifted:	40 lbs.	70 lbs.	150 lbs.

With Lever A you could only lift a 40-lb. load because

you applied the least amount of effort force to it	it had the smallest mechanical advantage	it had the largest mechanical advantage
______	______	______
______	X	______

139.

	Lever A	Lever B	Lever C
Effort force:	5 lbs.	5 lbs.	5 lbs.
Mechanical advantage:	7	4	2
Load lifted:	35 lbs.	20 lbs.	10 lbs.

With Lever A you can lift the heaviest load because

you applied the most effort force to it	it had the smallest mechanical advantage	it had the largest mechanical advantage
______	______	______
______	______	X

140.

You only want to apply a 10-lb. effort force to a lever.

In order to lift the heaviest load with only that amount of effort force you should pick the lever which has

the smallest mechanical advantage	the largest mechanical advantage
______	______
______	X

141.

You can apply a 7-lb. effort force to these levers.

	Lever A	Lever B
Mechanical advantage:	2	4

Lever B will let you lift the

smaller load	heavier load
______	______
______	X

142.

	Lever A	Lever B	Lever C
Mechanical advantage:	2	6	8
Effort force:	8 lbs.	8 lbs.	8 lbs.
COMPUTE THE LEVER FORCE:	16 LBS.	48 LBS.	64 LBS.

EDIT THIS SENTENCE

You can lift the heaviest load with Lever C because it has the smallest mechanical advantage.

If the underlined part is correct, COPY the underlined words.

If the underlined part is incorrect, CHANGE the underlined words.

LARGEST MECHANICAL ADVANTAGE

143.

A man applies the same effort force to different levers.

EDIT THIS SENTENCE

The man can lift the heaviest load with the lever that has the smallest mechanical advantage.

If the underlined part is correct, COPY the underlined word.

If the underlined part is incorrect, CHANGE the underlined word.

LARGEST

144.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	10 lbs.	10 lbs.
Mechanical advantage:	4	7	12

The heaviest load will be lifted by Lever C because IT HAS THE LARGEST MECHANICAL ADVANTAGE.

145.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	20 lbs.	30 lbs.
Mechanical advantage:	4	4	4

Note that the mechanical advantage of all three levers is the same.

Which lever will produce the largest lever force?

A	B	C
		X

You can lift the heaviest load with Lever C because

the effort force is biggest	the mechanical advantage is biggest
X	

146.

	Lever A	Lever B	Lever C
Effort force:	5 lbs.	8 lbs.	20 lbs.
Mechanical advantage:	10	10	10

The smallest load will be lifted by Lever

A	B	C
X		

Because,

the effort force is the smallest	the effort force is the biggest
X	

147.

The mechanical advantage is the same for several different levers.

You can lift the heaviest load with the lever to which you apply

the smallest effort force	the largest effort force
	X

148.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	15 lbs.	20 lbs.
Mechanical advantage:	5	5	5

With Lever A you will lift

the smallest load	the heaviest load
X	

Because,

the effort force is smallest	the effort force is biggest
X	

149.

	Lever A	Lever B	Lever C
Effort force:	2 lbs.	6 lbs.	9 lbs.
Mechanical advantage:	3	3	3

The heaviest load will be lifted by Lever C because

the effort force is biggest	the mechanical advantage is biggest
X	

150.

	Lever A	Lever B	Lever C
Effort force:	9 lbs.	12 lbs.	17 lbs.
Mechanical advantage:	3	3	3

EDIT THIS SENTENCE

You can lift the heaviest load with Lever C because the mechanical advantage is biggest.

If the underlined part is correct, COPY the underlined words.

____

If the underlined part is incorrect, CHANGE the underlined words.

EFFORT FORCE

151.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	20 lbs.	4 lbs.
Mechanical advantage:	7	7	7

The smallest load will be lifted by Lever C because THE EFFORT FORCE IS SMALLEST.

152.

	Lever A	Lever B
Effort force:	5 lbs.	2 lbs.
Mechanical advantage:	6	4

Compare the effort force for both levers. Now compare the mechanical advantage for both levers.

Lever A will lift the larger load because

only the effort force is bigger	only the mechanical advantage is bigger	both effort force and mechanical advantage are bigger
		X

153.

	Lever A	Lever B
Effort force:	4 lbs.	2 lbs.
Mechanical advantage:	x3	x6
Lever force:	= 12 LBS. Fill in	12 LBS. Fill in

Both levers will lift the same size load.	Lever A will lift a larger load.	Lever B will lift a larger load.
X		

154.

	Lever A	Lever B
Effort force:	7 lbs.	5 lbs.
Mechanical advantage:	4	6
Which one will lift the biggest load?	___	X

The reason is

7 is bigger than 5	6 is bigger than 4	5 x 6 is bigger than 7 x 4
___	___	X

155.

	Lever A	Lever B	Lever C
Effort force:	7 lbs.	5 lbs.	4 lbs.
Mechanical advantage:	2	5	11
Fill in the lever force:	14 LBS.	25 LBS.	44 LBS.

The biggest load can be lifted by Lever C because

1) the effort force is largest ___
2) effort force x mechanical advantage produces the largest lever force X
3) the mechanical advantage is largest ___

156.

	Lever A	Lever B	Lever C
Effort force:	2 lbs.	5 lbs.	4 lbs.
Mechanical advantage:	10	5	9

The biggest load can be lifted by

Lever A	Lever B	Lever C
___	___	X

Because

the effort force is largest	the mechanical advantage is largest	effort force x mechanical advantage is largest
___	___	X

157.

	Lever A	Lever B	Lever C
Effort force:	10 lbs.	20 lbs.	3 lbs.
Mechanical advantage:	6	2	9

EDIT THIS SENTENCE

Lever A will lift the largest load because it has the largest mechanical advantage and the largest effort force.

If the underlined part is correct, COPY the underlined words.

___

If the underlined part is incorrect, CHANGE the underlined words.

EFFORT FORCE X MECHANICAL ADVANTAGE IS BIGGEST

158.

If you apply the same effort force to different levers, the lever which will lift the largest load is the one which HAS THE LARGEST MECHANICAL ADVANTAGE.

159.

The way to find out just how big a load a lever can lift is to MULTIPLY EFFORT FORCE TIMES MECHANICAL ADVANTAGE.

160.

If different levers have the same amount of mechanical advantage, the lever which will lift the largest load is the one to which YOU APPLY THE LARGEST EFFORT FORCE.

161.

Most levers have different amounts of mechanical advantage.

If you have to lift a heavy load, which lever would you pick and why?

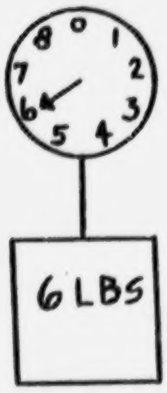
YOU WOULD PICK THE LEVER WITH THE LARGEST MECHANICAL ADVANTAGE, BECAUSE IT WOULD LET YOU USE THE LEAST AMOUNT OF EFFORT FORCE.

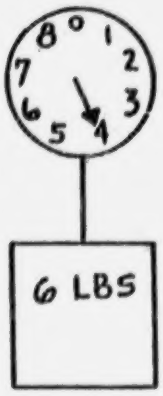
Studies #1 & #2

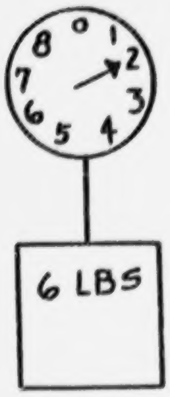
VISUAL ANSWER BOOKLET

PAGE 1

○ ○ ○

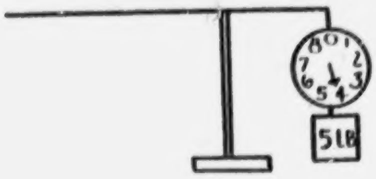

8 0 1 2 3 4 5 6 7
6 LBS


8 0 1 2 3 4 5 6 7
6 LBS

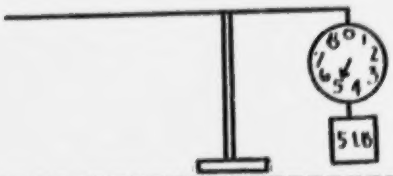

8 0 1 2 3 4 5 6 7
6 LBS

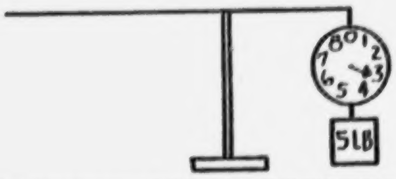
PAGE 2

○



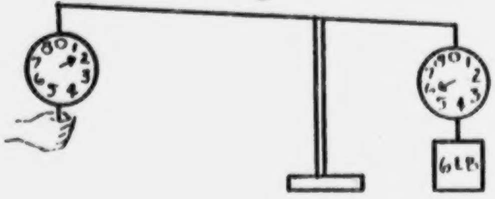
○ ○



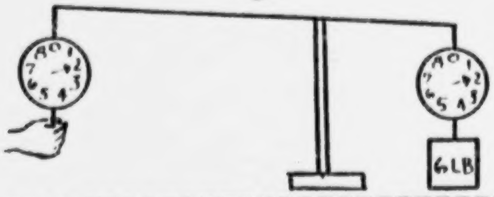


PAGE 3

○

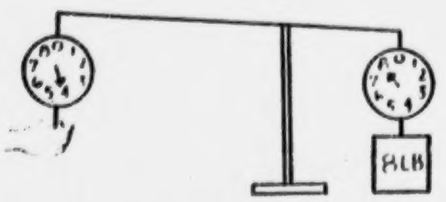


○

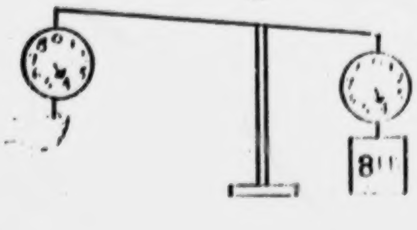


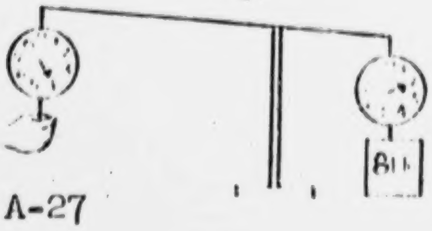
PAGE 4

○

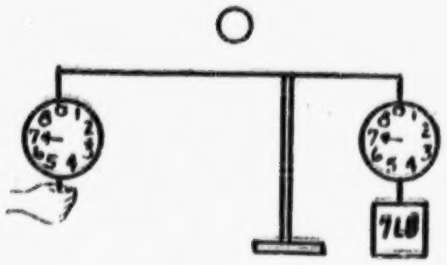


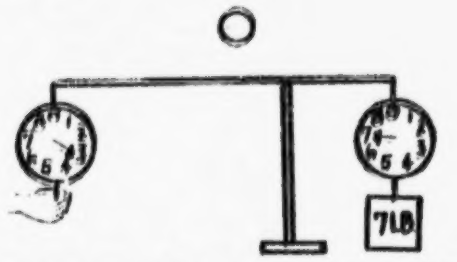
○ ○



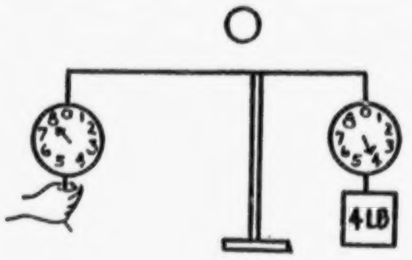


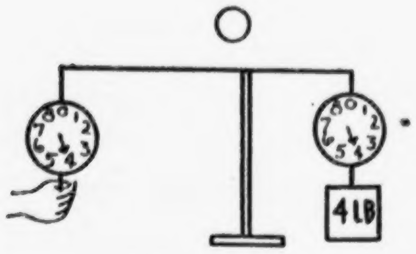
PAGE 5

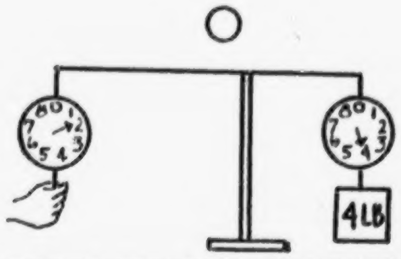




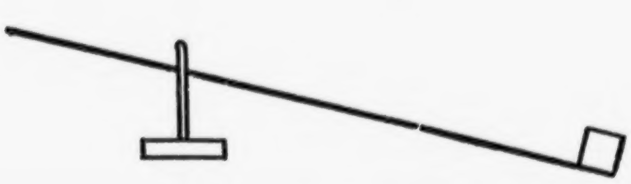
PAGE 6



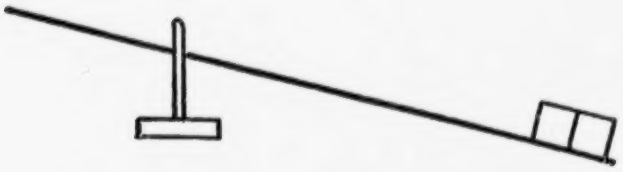




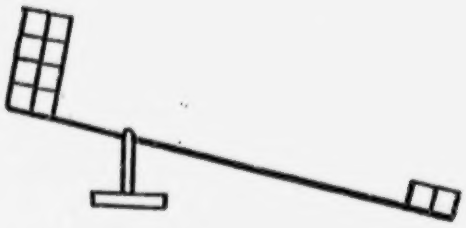
PAGE 7



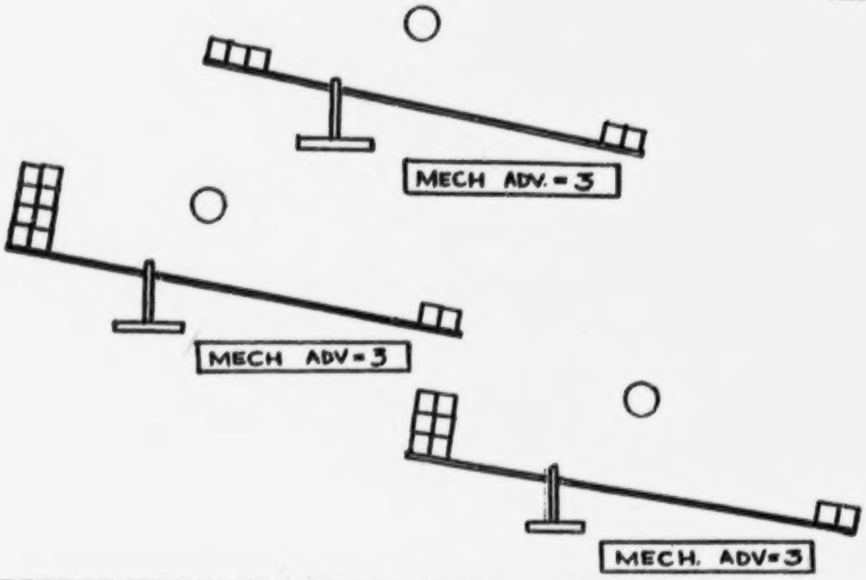
PAGE 8



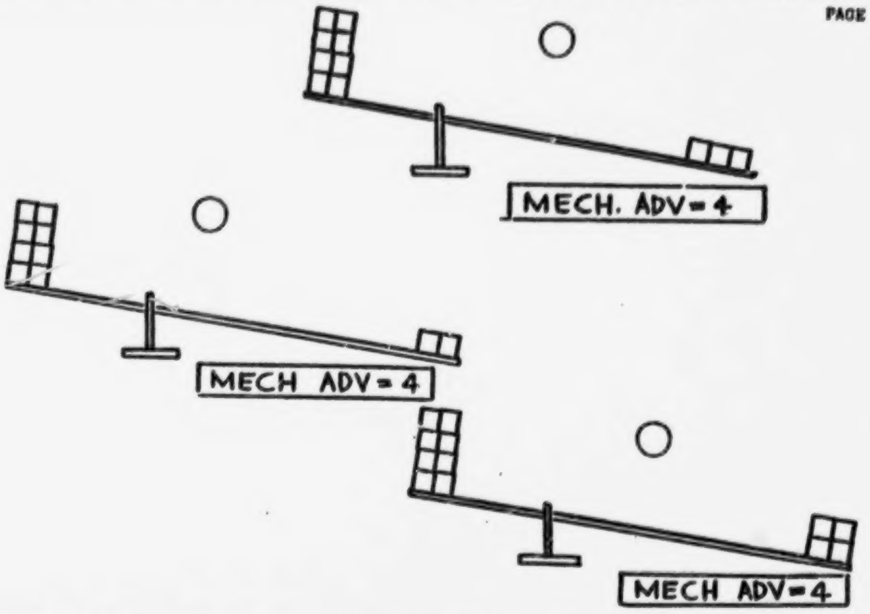
PAGE 9



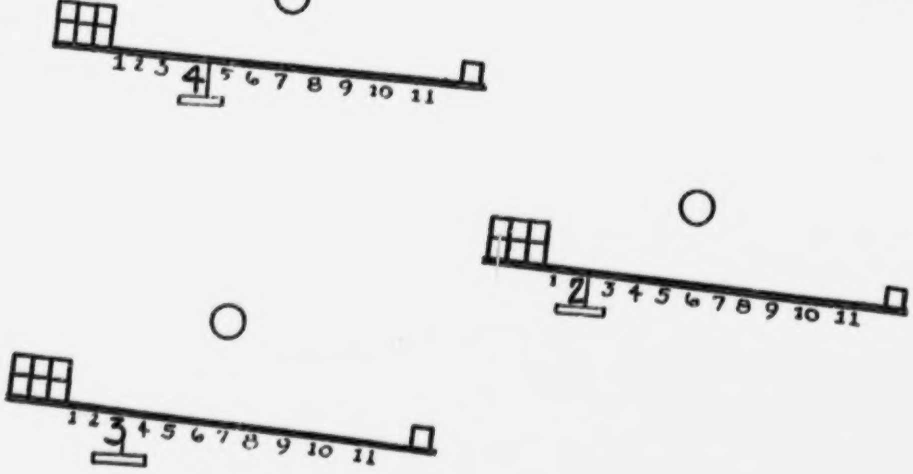
PAGE 10


MECH ADV. = 3
MECH ADV = 3
MECH. ADV = 3

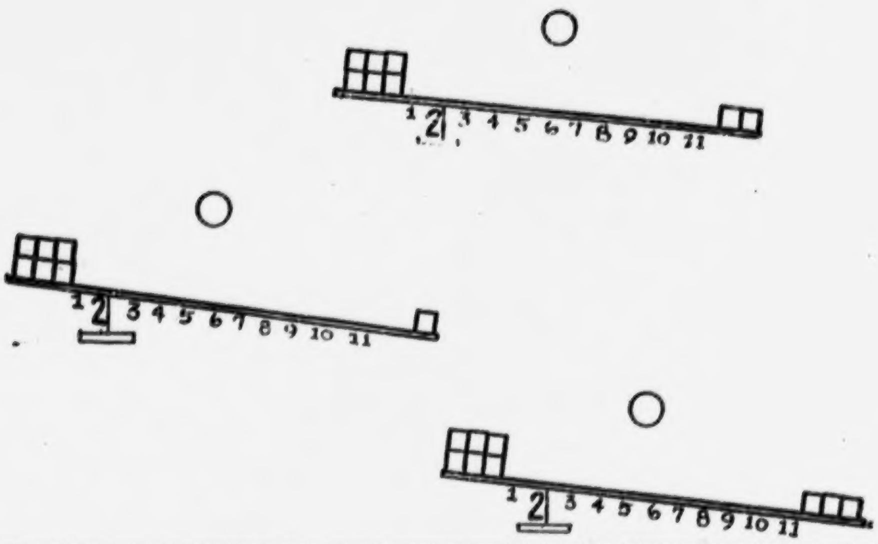
PAGE 11


MECH. ADV = 4
MECH ADV = 4
MECH ADV = 4

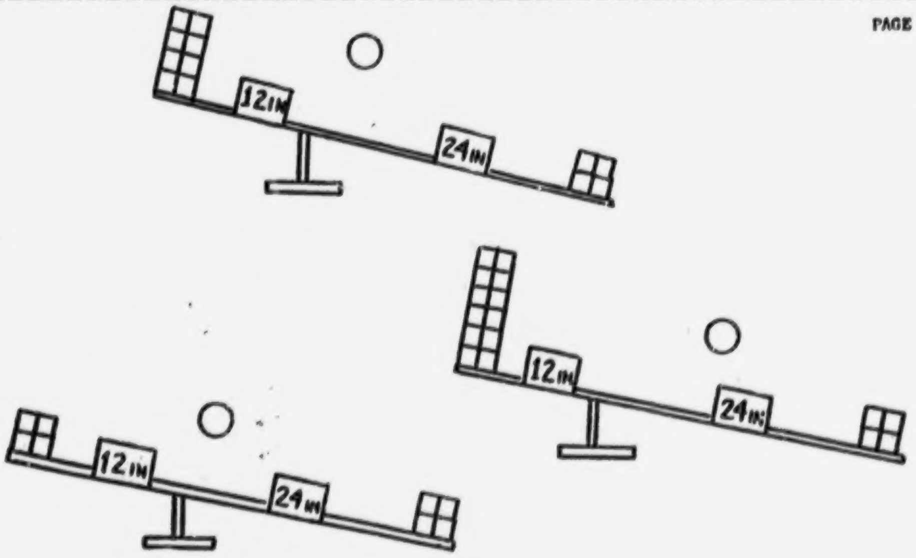
PAGE 12


1 2 3 4 5 6 7 8 9 10 11
1 2 3 4 5 6 7 8 9 10 11
1 2 3 4 5 6 7 8 9 10 11

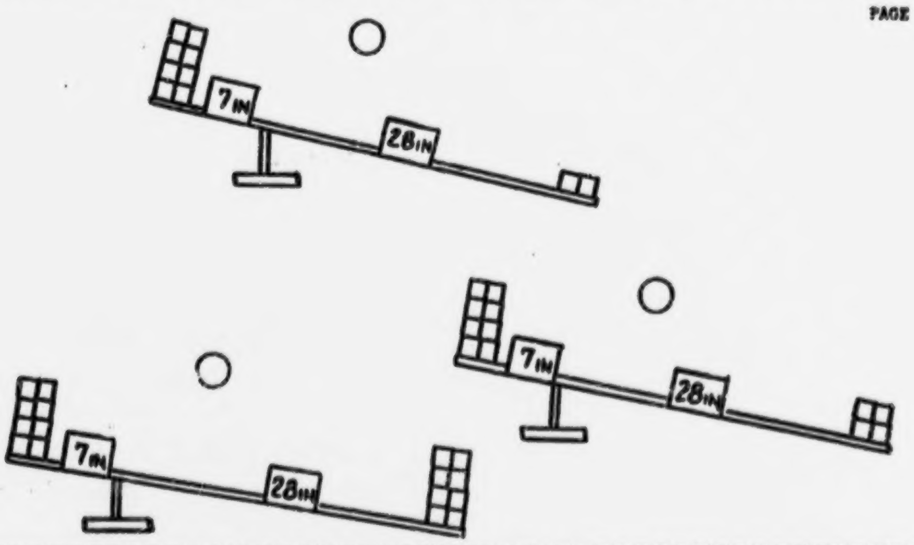
PAGE 13


1 2 3 4 5 6 7 8 9 10 11
1 2 3 4 5 6 7 8 9 10 11
1 2 3 4 5 6 7 8 9 10 11

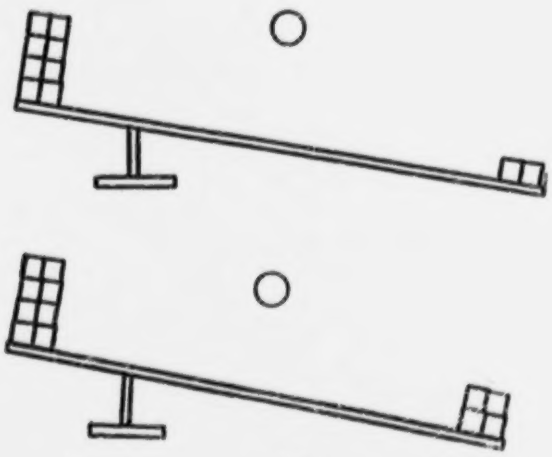
PAGE 14


12IN
24IN
12IN
24IN
12IN
24IN

PAGE 15

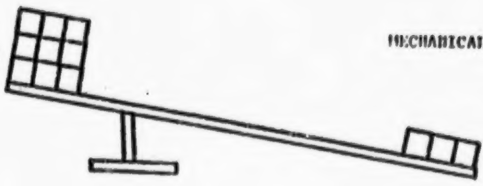

7IN
28IN
7IN
28IN
7IN
28IN

PAGE 16



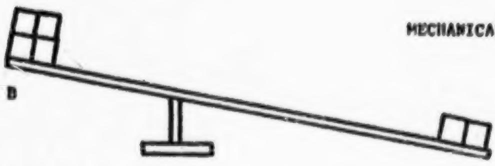
PAGE 17

LEVER A



MECHANICAL ADVANTAGE = ______

LEVER B



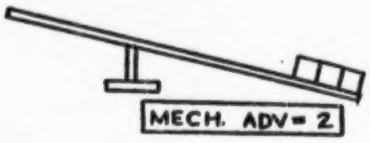
MECHANICAL ADVANTAGE = ______

Put an X next to the lever which has more mechanical advantage. ○ A ○ B

PAGE 18

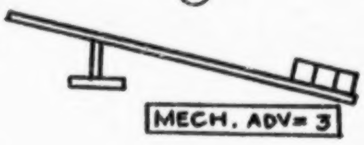
○

LEVER A



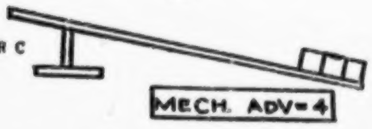
○

LEVER B



○

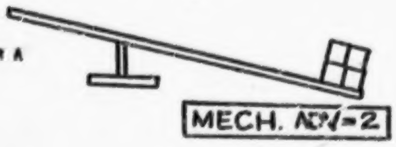
LEVER C



PAGE 19

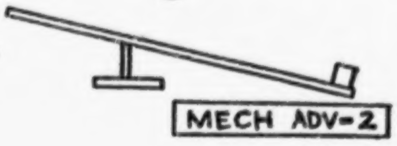
○

LEVER A



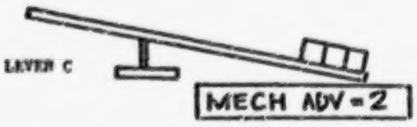
○

LEVER B



○

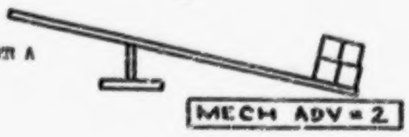
LEVER C



PAGE 20

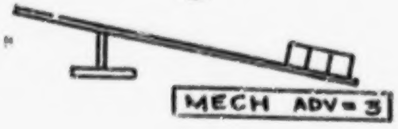
○

LEVER A



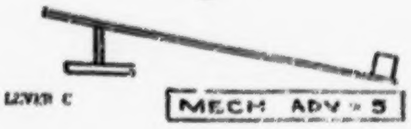
○

LEVER B



○

LEVER C



Study #1

LEVERS*

Verbal Version

1.

To lift a 5-lb. box by hand, a man must apply a 5-lb. force to the box.

Put an X in the space which shows how much force a man must apply to lift an 8-lb. box.

5 lbs.	8 lbs.	10 lbs.
	X	

2.

How much force must a man apply to lift a 50-lb. sack of flour?

50 lbs.	55 lbs.	60 lbs.
X		

3.

How much force must a man apply to lift a 24-1/2 lb. bag of groceries?

24 lbs.	24-1/2 lbs.	25 lbs.
	X	

4.

In each space write the number of lbs. of force that must be applied to lift each load.

10-lb. load	15-lb. load	20-lb. load
10	15	20

5.

To lift a 20-lb. box, a man must apply a 20-lb. force to the box.

What happens if he applies only a 15-lb. force to the 20-lb. box?

box is lifted	box does not move
	X

6.

To lift a 10-lb. box with a lever, the lever must apply a 10-lb. lever force to the box.

How much lever force must be applied to lift an 11-lb. load?

10 lbs.	11 lbs.	12 lbs.
	X	

7.

To lift a 40-lb. load of cement with a lever, how much lever force must be applied to the load?

30 lbs.	35 lbs.	40 lbs.
		X

8.

To lift a 27-3/4 lb. box with a lever, how much lever force must be applied to the box?

27-1/2 lbs.	27-3/4 lbs.	28 lbs.
	X	

---

*The frames reproduced here are those which were presented to the subjects as confirmation frames after they had made their own responses. X's are used to indicate the correct multiple choice responses.

9.

To lift a 200-lb. load of bricks, how much lever force must be applied to the load of bricks?

200 lbs.	225 lbs.	250 lbs.
X		

10.

What would happen if a 100-lb. lever force was applied to a 150-lb. load?

lever raises the load	load does not move
	X

11.

To lift a 70-lb. load by hand, the hand force applied to the load must be equal to 70 lbs.

To lift the same 70-lb. load with a lever, the lever force applied to the load must be

less than 70 lbs.	equal to 70 lbs.	much more than 70 lbs.
	X	

12.

A 20-lb. effort force applied to one end of a lever will lift a 40-lb. rock at the other end.

Therefore, if a small effort force is applied at one end of a lever, the lever applies a force to the load at the other end which is

bigger than the effort force	smaller than the effort force
X	

13.

	effort force applied to the lever	lever force applied to the load
Lever A	30 lbs.	90 lbs.

Look at the chart above.

A 90-lb. lever force is applied by Lever A, even though the effort force applied to the lever is

smaller than the lever force	bigger than the lever force
X	

14.

	effort force applied to the lever	lever force applied to the load
Lever B	10 lbs.	50 lbs.

In this chart, the effort force applied to the lever is only 10 lbs.; the lever force applied to the load is

smaller than the effort force	bigger than the effort force
	X

15.

	effort force applied to the lever	lever force applied to the load
Lever C	20 lbs.	100 lbs.

From the chart above, a 100-lb. lever force is applied by Lever C. The effort force needed to produce this lever force is

bigger than the lever force	equal to the lever force	smaller than the lever force
		X

16.

If a small effort force is applied at one end of a lever, the lever applies a bigger lever force to the load at the other end.

yes	no
X	

17.

An effort force of only 100 lbs. applied to one end of a lever will lift a 500-lb. safe on the other end because a lever applies a lever force which is

smaller than the effort force	equal to the effort force	bigger than the effort force
		X

18.

If a small boy applies only a 2-lb. effort force to the empty end of a lever, a 10-lb. box at the other end will be lifted, because by applying only a small effort force to a lever, the lever can apply a *lever force to the load which is*

bigger than the effort force	equal to the effort force	smaller than the effort force
X		

19.

To lift a 20-lb. box, you can apply an effort force to the lever which is less than 20 lbs. and still raise the box because the lever will apply

a lever force smaller than the effort force	a lever force bigger than the effort force
	X

20.

A 10-lb. effort force applied to the empty end of a lever raised a 40-lb. load at the other end because

the lever took the effort force and made it smaller	the lever took the effort force and made it bigger
	X

21.

An effort force of 10 lbs. applied at one end of the lever made enough lever force at the other end to lift a 40-lb. load.

Therefore, we can say that the effort force was increased

2 times	4 times	6 times
	X	

22.

If a 10-lb. effort force at one end is enough to lift a 30-lb. load at the other end, the lever increased the effort force

2 times	3 times	4 times
	X	

23.

If a 10-lb. effort force applied at one end is enough to lift 50 lbs. at the other end, the lever made this effort force

5 times bigger	10 times bigger	50 times bigger
X		

24.

If a 20-lb. effort force lifts a 60-lb. load, the effort force was made

2 times bigger	3 times bigger	4 times bigger
	X	

25.

If 20 lbs. of effort force applied at one end of the lever lifts a 100-lb. load at the other end, it is because the effort force was made

5 times bigger	20 times bigger	100 times bigger
X		

26.

(20 x 4 = 80)

If an effort force of 20 lbs. is made 4 times bigger, it will lift

a 20-lb. load	a 40-lb. load	an 80-lb. load
		X

27.

If an effort force of 20 lbs. is made 6 times bigger, it will lift a

60-lb. load	120-lb. load	160-lb. load
	X	

28.

If an effort force of 10 lbs. is made 7 times bigger, it will lift a

10-lb. load	70-lb. load	170-lb. load
	X	

29.

If an effort force of 30 lbs. is made 3 times bigger, it will lift a

30-lb. load	60-lb. load	90-lb. load
		X

30.

When a lever increases an effort force 2 times, the lever has a mechanical advantage of 2.

A lever which increases an effort force 3 times, has a mechanical advantage of

1	2	3
		X

31.

A lever which increases an effort force 4 times, has a mechanical advantage of

2	4	6
	X	

32.

If the effort force applied by 2 lbs. is increased enough to lift an 8-lb. load, the lever has a mechanical advantage of 4.

If the effort force applied by 2 lbs. is increased enough to lift a 10-lb. load, the lever has a mechanical advantage of

2	5	10
	X	

33.

If the effort force applied by 4 lbs. is increased enough to lift a 12-lb. load, the lever has a mechanical advantage of

2	3	4
	X	

34.

If a lever has a mechanical advantage of 3, it means that a 3-lb. effort force applied to the lever will allow the lever to lift a 9-lb. load.

If a lever has a mechanical advantage of 5, it means that a 2-lb. effort force applied to the lever will allow the lever to lift a

2-lb. load	5-lb. load	10-lb. load
		X

35.

If a lever has a mechanical advantage of 2, it means that a 20-lb. effort force applied to the lever will let the lever lift a

20-lb. load	40-lb. load	50-lb. load
	X	

36.

If a lever has a mechanical advantage of 3, it means that an effort force of 30 lbs. applied to one end of a lever will lift a load at the other end of the lever weighing

10 lbs.	30 lbs.	90 lbs.
		X

37.

If a lever has a mechanical advantage of 2, a 20-lb. load on one end of a lever will be lifted by an effort force applied at the other end of the lever of only 10 lbs.

If a lever has a mechanical advantage of 4, a 40-lb. load on one end of a lever will be lifted by an effort force applied at the other end of the lever of only

10 lbs.	20 lbs.	40 lbs.
X		

38.

If a lever has a mechanical advantage of 3, a 90-lb. load on one end of a lever will be lifted if you apply an effort force at the other end of only

30 lbs.	60 lbs.	90 lbs.
X		

39.

If a 40-lb. load on one end of a lever is lifted by a 10-lb. effort force applied at the other end, the mechanical advantage of the lever is 4.

If a 60-lb. load on one end of a lever is lifted by a 20-lb. effort force applied at the other end, the mechanical advantage of the lever is

2	3	6
	X	

40.

If a 40-lb. load is lifted on one end of a lever by a 10-lb. effort force applied at the other end, the mechanical advantage of the lever is

4	6	10
X		

41.

If a lever has a mechanical advantage of 4, it means that any effort force applied to that lever will be increased

4 times	6 times	10 times
X		

42.

If the effort force applied to a lever is increased 5 times, a 100-lb. load at one end of the lever can be lifted by applying an effort force at the other end of only

5 lbs.	20 lbs.	100 lbs.
	X	

43.

With the fulcrum in the center, a 6-lb. force is balanced by a 6-lb. effort force.

With the fulcrum in the center, a 4-lb. load is balanced by an effort force of

4 lbs.	5 lbs.	6 lbs.
X		

44.

When the fulcrum is moved away from the center, closer to the load, a 4-lb. load can be lifted by applying an effort force of only 2 lbs. to the lever.

To lift the same 4-lb. load by applying an effort force of only 1 lb. to the lever, the fulcrum must

be moved away from the load	remain where is it	be moved still closer to the load
		X

45.

If the fulcrum is moved away from the center, closer to the load, a 6-lb. load can be lifted by applying an effort force of 3 lbs. to the lever.

To lift this same 6-lb. load by applying an effort force of only 1 lb. to the lever, the fulcrum must

be moved away from the load	remain where it is	be moved still closer to the load
		X

46.

If the fulcrum is moved away from the center, closer to the load, an 8-lb. load can be lifted by applying an effort force of 4 lbs. to the lever.

To lift the same 8-lb. load by applying an effort force of 2 lbs. to the lever, the fulcrum should

be moved closer to the center	remain where it is	be moved closer to the load
		X

47.

A 6-lb. load is balanced by applying an effort force of 6 lbs. to the lever when the fulcrum is exactly in the center.

A 6-lb. load can be lifted in the air by applying an effort force of 3 lbs. when the fulcrum

is moved toward the load	remains in the center	is moved toward the effort force
X		

48.

The total length of a lever is 30 inches. If the fulcrum is placed 6 inches from the load, we would have a 6" lever arm. The effort arm would be

24" long	25" long	26" long
X		

49.

The total length of a lever is 25 inches. If the fulcrum is placed 10" from the load, we would have a 10" lever arm. The effort arm would be

10" long	15" long	25" long
	X	

50.

The total length of a lever is 30". The lever arm is 10" long, the effort arm is 20" long. Thus, the effort arm is

2 times longer than the lever arm	3 times longer than the lever arm	equal to the lever arm
X		

51.

The total length of a lever is 60". The lever arm is 15" long, the effort arm is 45" long. Thus, the effort arm is

2 times longer than the lever arm	3 times longer than the lever arm	equal to the lever arm
	X	

52.

The total length of a lever is 80". The lever arm is 20" long, the effort arm is 60" long. Thus, the effort arm is

3 times longer than the lever arm	6 times longer than the lever arm	equal to the lever arm
X		

53.

The effort arm of a lever is 27" long. The lever arm is 9" long. The effort arm is therefore 3 times longer than the lever arm.

When the effort arm is 3 times longer than the lever arm, the lever increases the effort force 3 times.

If the effort arm is 30" long, and the lever arm is 6" long, the lever increases the effort force

4 times	5 times	6 times
	X	

54.

	length of the lever arm	length of the effort arm
Lever A	7" long	21"

From the chart above, we can see that Lever A will increase the effort force

3 times	5 times	7 times
X		

55.

	length of the lever arm	length of the effort arm
Lever B	3" long	18"

From this chart, we can see that Lever B will increase the effort force

3 times	6 times	9 times
	X	

56.

	length of the lever arm	length of the effort arm
Lever C	6" long	12"

Lever C will increase the effort force

2 times	4 times	6 times
X		

57.

	length of the lever arm	length of the effort arm
Lever A	10"	20"

If a 4-lb. effort force was applied to Lever A above, it would be increased

2 times	5 times	10 times
X		

Thus, it would lift a load of

4 lbs.	6 lbs.	8 lbs.
		X

58.

	length of the lever arm	length of the effort arm
Lever B	9"	45"

If a 3-lb. effort force was applied to Lever B above, it would be increased

2 times	5 times	9 times
	X	

Thus, it would lift a load of

3 lbs.	15 lbs.	45 lbs.
	X	

59.

	length of the lever arm	length of the effort arm
Lever C	20"	60"

If a 2-lb. effort force was applied to Lever C above, it would be increased

3 times	6 times	10 times
X		

Thus, it would lift a load of

4 lbs.	6 lbs.	8 lbs.
	X	

60.

	effort force applied	weight of load lifted
Lever A	1 lb.	6 lbs.
Lever B	3 lbs.	6 lbs.

The mechanical advantage of Lever A above is

1	3	6
		X

The mechanical advantage of Lever B is

2	4	6
X		

The lever with the biggest mechanical advantage is

Lever A	Lever B
X	

61.

	effort force applied	weight of load lifted
Lever A	3 lbs.	9 lbs.
Lever B	1 lb.	5 lbs.

The mechanical advantage of Lever A above is

3	6	9
X		

The mechanical advantage of Lever B is

1	3	5
		X

The lever with the smallest mechanical advantage is

Lever A	Lever B
X	

62.

	effort force applied	weight of load lifted
Lever A	20 lbs.	100 lbs.
Lever B	20 lbs.	40 lbs.

In the chart above, both levers have an effort force of 20 lbs., but the biggest load is lifted by

Lever A	Lever B
X	

Therefore, the lever with the biggest mechanical advantage is

Lever A	Lever B
X	

63.

	effort force applied	weight of load lifted
Lever A	3 lbs.	6 lbs.
Lever B	2 lbs.	10 lbs.

In the chart above, the lever that lifts the biggest load is

Lever A	Lever B
	X

The lever which has the biggest mechanical advantage is

Lever A	Lever B
	X

64.

	effort force applied	weight of load lifted
Lever A	2 lbs.	8 lbs.
Lever B	4 lbs.	8 lbs.

The lever with the biggest mechanical advantage is

Lever A	Lever B
X	

65.

	effort force applied	weight of load lifted
Lever A	30 lbs.	60 lbs.
Lever B	10 lbs.	60 lbs.
Lever C	20 lbs.	60 lbs.

From the chart above, the lever with the biggest mechanical advantage is

Lever A	Lever B	Lever C
	X	

66.

	effort force applied	weight of load lifted
Lever A	20 lbs.	40 lbs.
Lever B	30 lbs.	60 lbs.
Lever C	10 lbs.	50 lbs.

The lever with the biggest mechanical advantage is

Lever A	Lever B	Lever C
		X

67.

	mechanical advantage	effort force applied	weight of load lifted
Lever A	4	20 lbs.	80
Lever B	2	20 lbs.	40

From the chart above, both levers have an effort force of 20 lbs., but the lever with the biggest mechanical advantage is

Lever A	Lever B
X	

The largest load is lifted by

Lever A	Lever B
X	

68.

When the same amount of effort force is applied to two levers, the lever which will lift the largest load is the one which has the

biggest mechanical advantage	smallest mechanical advantage
X	

69.

	mechanical advantage	effort force applied
Lever A	3	10 lbs.
Lever B	2	10 lbs.
Lever C	5	10 lbs.

The lever which will lift the largest load is lever

A	B	C
		X

70.

	mechanical advantage	effort force applied
Lever A	4	5 lbs.
Lever B	6	5 lbs.
Lever C	2	5 lbs.

The lever which will lift the largest load is lever

A	B	C
	X	

71.

	mechanical advantage	effort force applied	weight of load lifted
Lever A	3	10 lbs.	30 lbs.
Lever B	3	30 lbs.	90 lbs.

From the chart above, both levers have the same mechanical advantage, but the effort force applied to Lever B is

larger	smaller
X	

The largest load is lifted by

Lever A	Lever B
	X

72.

When two levers have the same mechanical advantage, the lever which will lift the biggest load is the one to which

the smallest effort force is applied	the largest effort force is applied
	X

73.

	mechanical advantage	effort force applied
Lever A	3	2 lbs.
Lever B	3	3 lbs.
Lever C	3	1 lb.

The lever which will lift the biggest load is lever

A	B	C
	X	

74.

	mechanical advantage	effort force applied
Lever A	4	6 lbs.
Lever B	4	2 lbs.
Lever C	4	4 lbs.

The lever which will lift the biggest load is lever

A	B	C
X		

75.

	mechanical advantage		effort force applied		weight of load lifted
Lever A	4	x	3 lbs.	=	12 lbs.
Lever B	6	x	2 lbs.	=	12 lbs.

The mechanical advantage of the two levers is

the same	different
	X

The effort force applied to the two levers is

the same	different
	X

The load lifted by the two levers is

the same	different
X	

The reason is 4 x 3 = 12 and $\boxed{6}$ x $\boxed{2}$ also = 12.

76.

	mechanical advantage	effort force applied	weight of load lifted
Lever A	8	2 lbs.	16 lbs.
Lever B	4	4 lbs.	16 lbs.

The mechanical advantage of the two levers is

the same	different
	X

The effort force applied to the two levers is

the same	different
	X

The load lifted by the two levers is

the same	different
X	

The reason is $\boxed{8}$ x $\boxed{2}$ = 16 and
$\boxed{4}$ x $\boxed{4}$ = 16.

77.

	mechanical advantage	effort force applied	weight of load lifted
Lever A	3	5	15
Lever B	2	10	20

Lever A lifts a load of 15 lbs. while Lever B lifts a load of 20 lbs.

because $\boxed{3}$ x $\boxed{5}$ = 15; and

$\boxed{2}$ x $\boxed{10}$ = 20.

78.

	mechanical advantage	effort force applied
Lever A	2	8
Lever B	3	4
Lever C	5	4

The lever which will lift the heaviest load is lever

A	B	C
		X

Pre- and Post-Test - Study #1

ACHIEVEMENT TEST

Part I

1. Suppose you want to raise a 30-lb. load and you can use either one of two levers. Lever A has a mechanical advantage of 2; Lever B has a mechanical advantage of 5. It would be easier to use Lever _____, because

   ____
   (Use the words "EFFORT FORCE" in your answer.)

   ____

2. When we say one lever has more mechanical advantage than another, what does this mean? (Use the idea of "FORCE" in your answer.)

   ____

   ____

3. You have a choice of lifting the same heavy load by hand or with a lever. Which would you choose to do and why? (Use the word "FORCE" in your answer.)

   ____

   ____

4.
   a. Using a lever, a man can lift a 30-lb. load by applying an effort force of just 10 lbs. to the lever. If he wants to lift the same load and apply an effort force of less than 10 lbs., what must he do the lever?

      ____

      ____

   b. Why would this let him use an effort force of less than 10 lbs.?

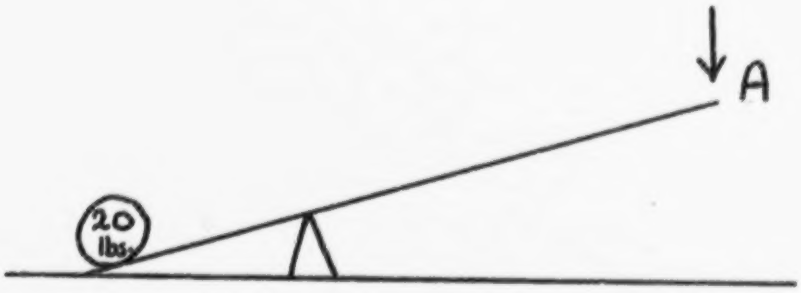
      ____

      ____

Part I

5. A man applied an effort force of 10 lbs. to a lever that had a mechanical advantage of 6. That means he could lift a load that weighed _____ lbs.

6. If the lever in the picture below has a mechanical advantage of 5, the rock can be raised by pushing down at A with an effort force of _____ lbs.

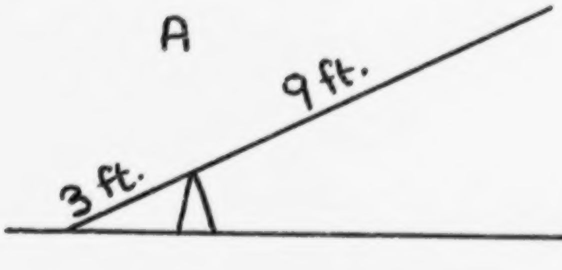


7. Which one of the levers below has the largest mechanical advantage? _____

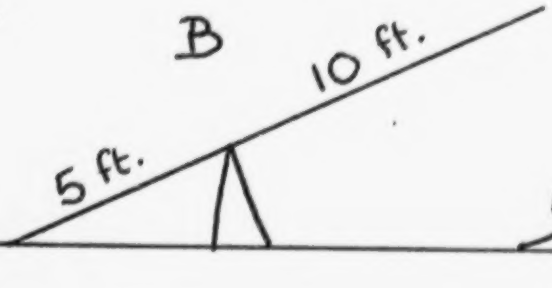
How can you tell? ____

____

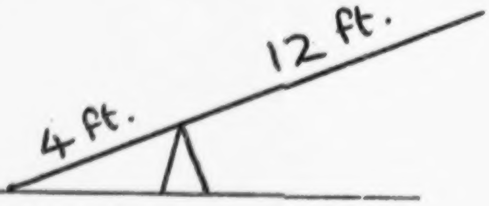
A



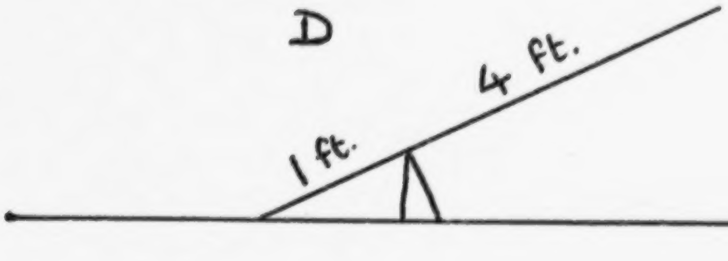
B



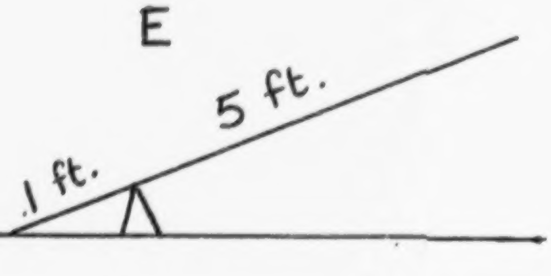
C



D

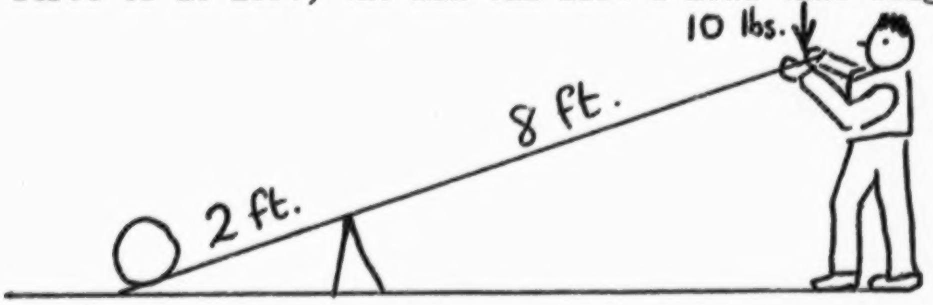


E

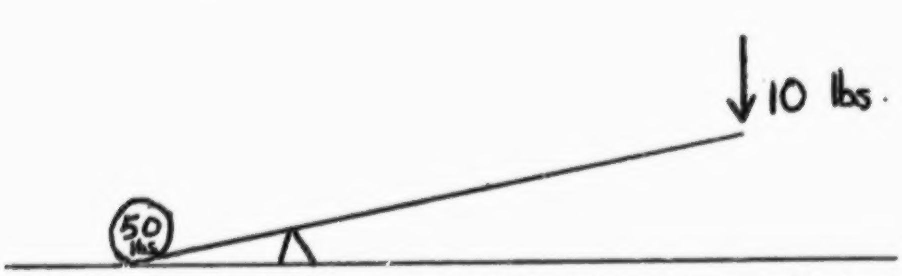


Part I

8. The lever below has a mechanical advantage of _____. Therefore, with an effort force of 10 lbs., the man can lift a load that weighs _____ lbs.



9. The lever below has a mechanical advantage of _____.

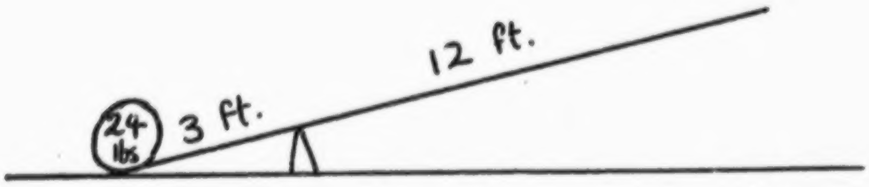


10. A man applies an effort force of 5 lbs. to a lever that increases his effort force 6 times. What does this tell us about that lever?

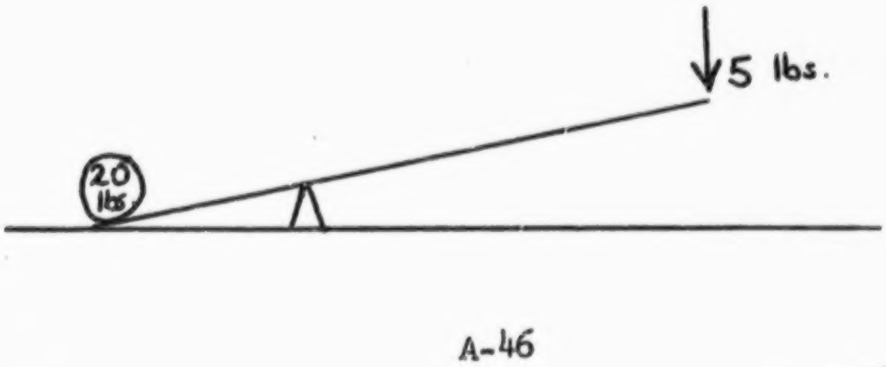
____

11. In the picture below, how much effort force will be needed to lift the load?

____

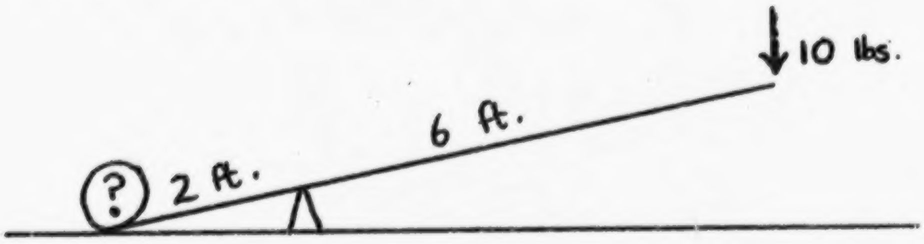


12. How many times is the effort force increased by the lever in the picture below? ______________



Part I

13. The lever below has a mechanical advantage of _____.
With an effort force of 10 lbs., how big a load can we raise? ________________


10 lbs.
6 ft.
2 ft.
?

14. You have to lift a 30-lb. load. You have 3 levers to choose from:

Lever	Mechanical Advantage
A	6
B	5
C	3

Which lever would you choose to lift the 30-lb. load with? Lever ____.
Why? (Use the word "FORCE" in your answer.)

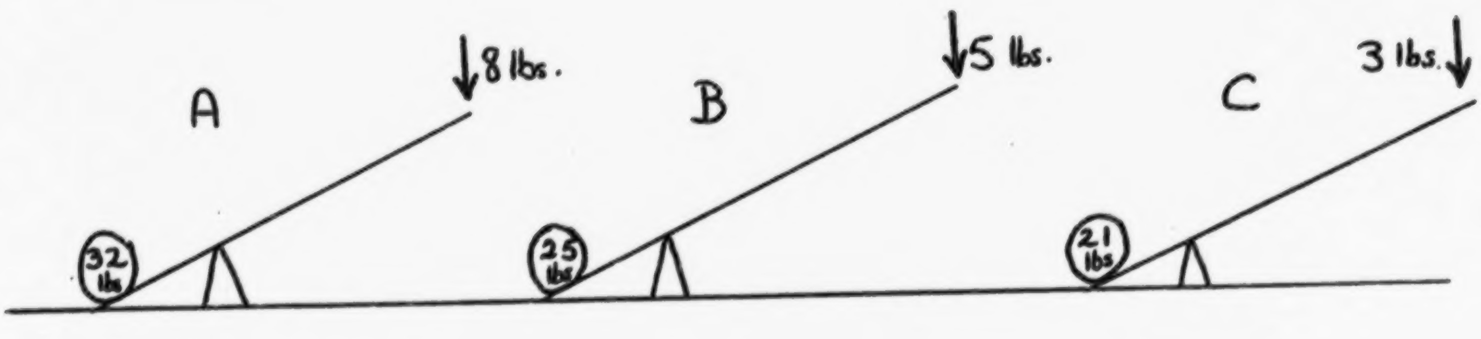
____

____

15. Which one of the levers below has the largest mechanical advantage? _____
Explain how you can tell.

____

____


A
8 lbs.
32 lbs
B
5 lbs.
25 lbs
C
3 lbs.
21 lbs

Part II

1. It's easier to raise a heavy load with a lever if we move the fulcrum closer to the load because
   ______ a. the lever arm becomes longer than the effort arm.
   ______ b. the effort force is increased a larger number of times.
   ______ c. the load gets reduced.
   ______ d. less lever force is needed.

2. Because a lever has a mechanical advantage, it is possible to
   ______ a. raise a load a large distance.
   ______ b. push the lever down a short distance.
   ______ c. apply a large effort force.
   ______ d. increase the length of the lever arm.
   ______ e. raise a heavy load with a small effort force.

3. The lever which has the largest mechanical advantage will
   ______ a. require the largest effort force.
   ______ b. require the smallest effort force.
   ______ c. reduce the lever force the most.
   ______ d. reduce the lever force the least.

4. The mechanical advantage of a lever can be changed by
   ______ a. applying a larger effort force.
   ______ b. reducing the weight of the load.
   ______ c. increasing the length of the effort arm.
   ______ d. applying a smaller effort force.
   ______ e. pushing the lever down farther.

Part II

5. We use levers because they have mechanical advantage. This means that by applying a certain amount of force to the lever, we can lift a load whose weight is

   ______ a. less than the force we applied to the lever.
   ______ b. equal to the force we applied to the lever.
   ______ c. greater than the force we applied to the lever.

6. The lever which requires the biggest effort force is the lever which

   ______ a. is the longest.
   ______ b. is the shortest.
   ______ c. has the smallest mechanical advantage.
   ______ d. has the largest mechanical advantage.
   ______ e. increases the effort force the most number of times.

7. When using a lever, the closer the fulcrum is to a load, the

   ______ a. shorter the effort arm is.
   ______ b. larger the mechanical advantage.
   ______ c. larger the effort force has to be.
   ______ d. smaller the load we can lift.

8. The reason we move the fulcrum closer to the load is that this reduces

   ______ a. the load.
   ______ b. the amount of effort force needed.
   ______ c. the lever force.
   ______ d. the number of times the effort force is increased.

Part II

9. Five different levers all have the same mechanical advantage. Put an X next to the one which will lift the smallest load.

Lever	Effort Force Applied
_____ A	3 lbs.
_____ B	4 lbs.
_____ C	5 lbs.
_____ D	6 lbs.
_____ E	7 lbs.

10. A man can lift a 25-lb. box with an effort force of 5 lbs. If he moved the fulcrum farther away from the load, he would then

______ a. use less effort force.

______ b. use more effort force.

______ c. use the same amount of effort force.

Part III

Many familiar objects, some of which you have often used yourself, are types of levers. This next section of the test includes some of these objects which all act as levers.

1. Based on the information given to you in the pictures below, which of the two hammers has the largest mechanical advantage? ________

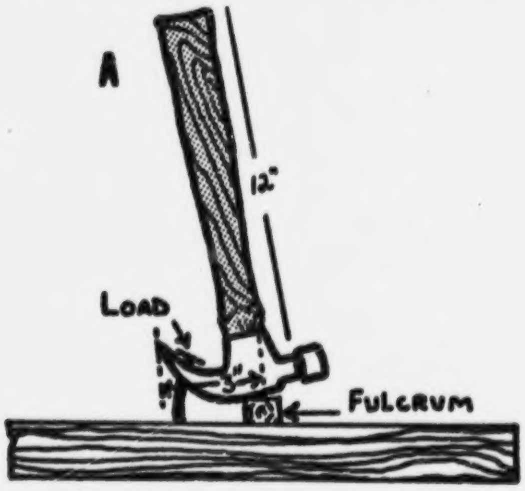
   How did you figure out which hammer had the biggest mechanical advantage?

   ____

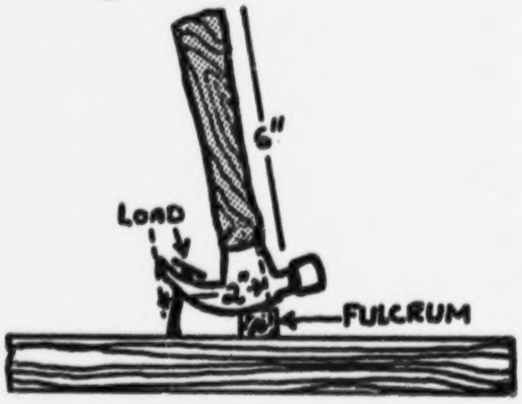
   If you had your choice of the two hammers pictured below, which could you choose to remove a nail from a plastered wall? ________

   If the nail had been cemented in place, which hammer would you choose? ________

A



B

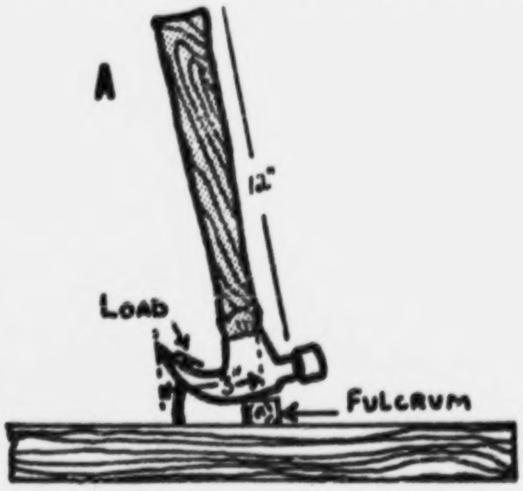


2. Look at figure A below.

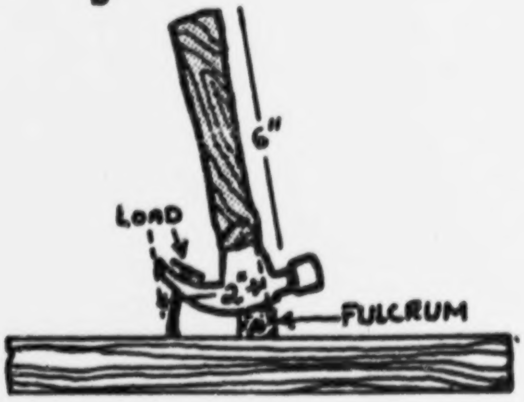
   If a man applied a 10 lb. force to this hammer, how many lbs. of force would be applied to the nail? ________

   If 10 lbs. of force was applied to the other hammer in figure B, how many lbs. of force would be applied to that nail? ________

A



B



Part III

3. Which pair of scissors below has the largest mechanical advantage? ______

Why did you decide that this pair of scissors had the largest mechanical advantage?

______

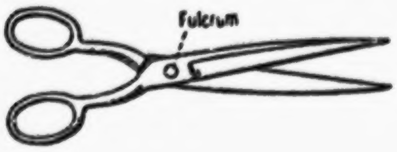
If both pairs of scissors were available, which pair would you use to cut a piece of tin? ______

Which pair would you use to cut a piece of cloth? ______

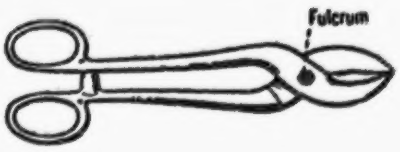
How did you decide which scissors to use to cut a piece of tin?

______

A



B

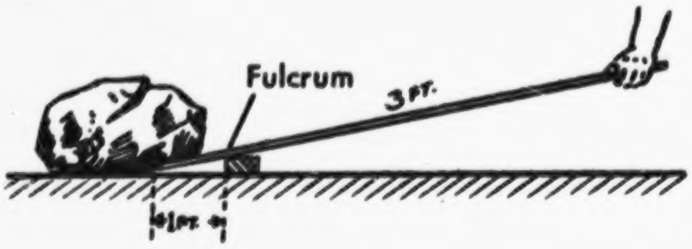


4. The mechanical advantage of the crowbar in figure A below is ______.

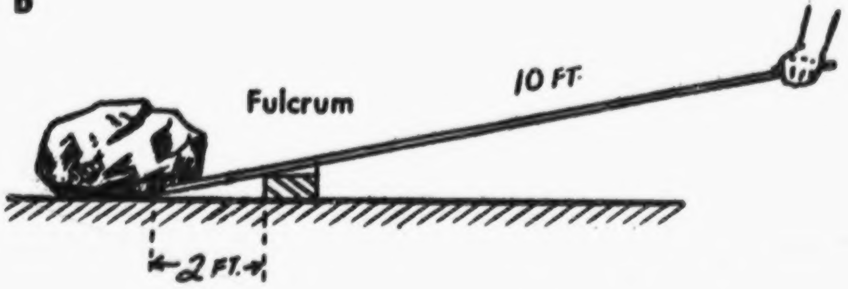
The mechanical advantage of the other crowbar is ______.

If crowbar B is to lift the 25 lb. rock, the effort force you would need to apply to the crowbar is ______ lbs.

A



B



Part III

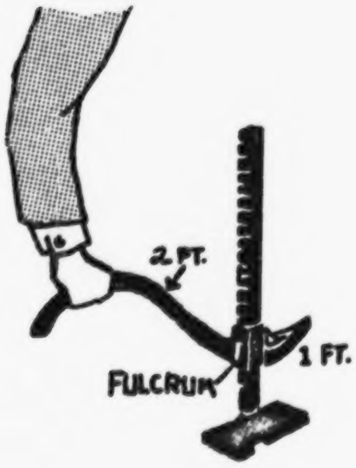
5. If you wanted to make use of both of the automobile jacks pictured below, which one could you use to jack up a small foreign car? ________

Which one would you use to jack up a heavy car? ________

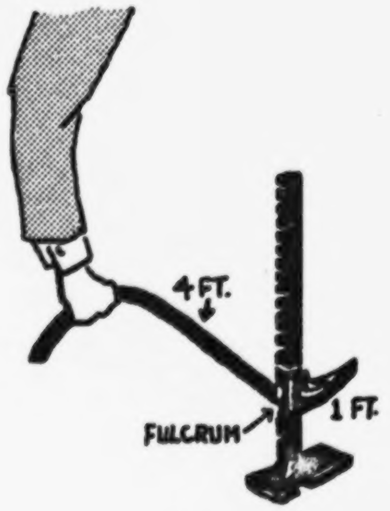
Look at figure A.

If a man applied 10 lbs. of force to the handle of this jack, how many lbs. of force would the jack apply to the car? __________

A

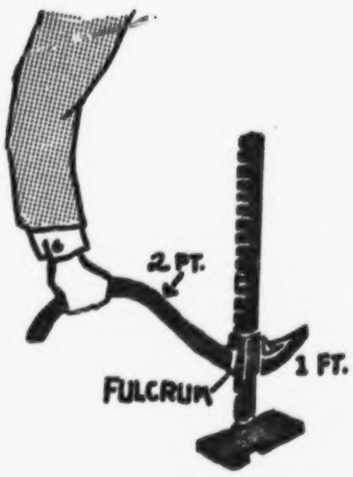

2 FT.
1 FT.
FULCRUM

B

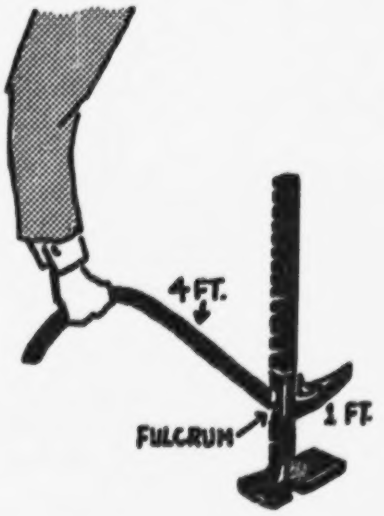

4 FT.
1 FT.
FULCRUM

6. Which jack pictured below could apply an 80 lb. force to a car, if an effort force of only 20 lbs. was applied to the jack? ________

A


2 FT.
1 FT.
FULCRUM

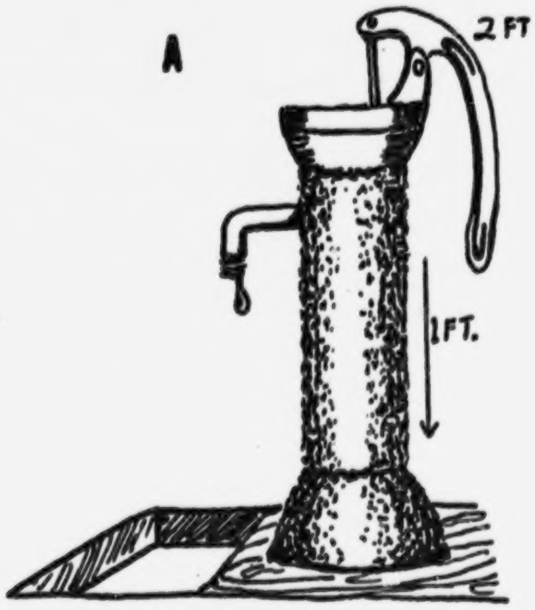
B

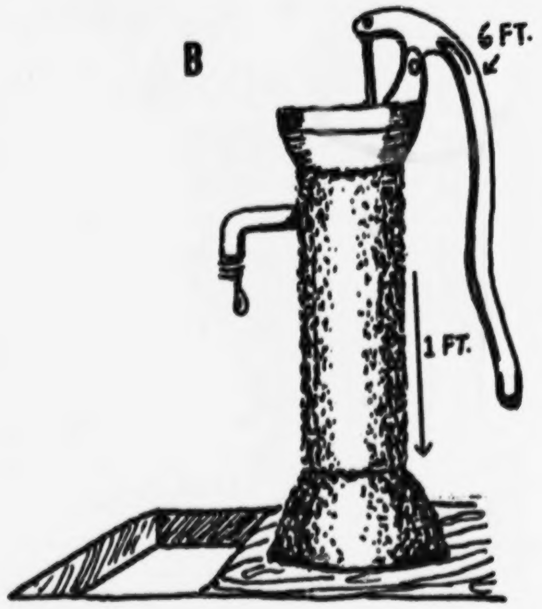

4 FT.
1 FT.
FULCRUM

Part III

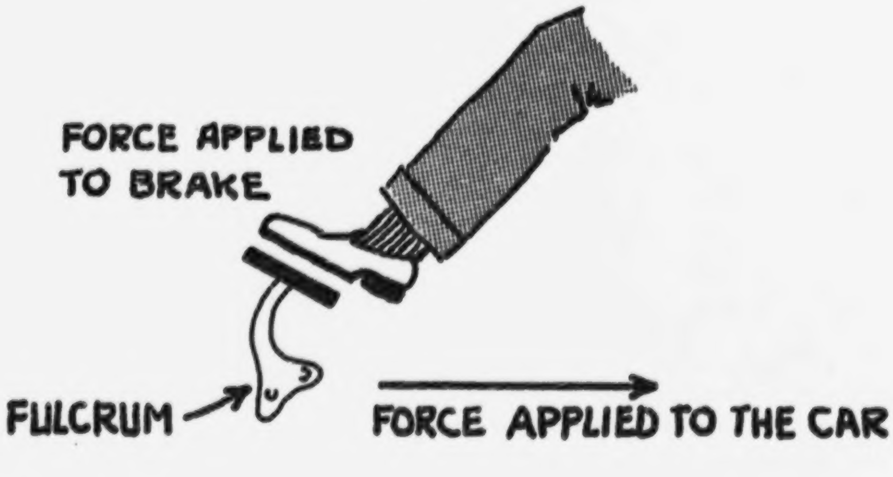
7. If you wanted the pump in figure A to apply a force of 10 lbs. to the water in the well, how much force would you apply to the handle? _______

To get a bucket of water from the well, which pump would require the largest amount of effort force? _______





8. A man applies a force of 20 lbs. to the brake pedal of an automobile. The brake then applies a force of 2,000 lbs. to stop the automobile. Thus the mechanical advantage of this brake is _______.


FORCE APPLIED TO BRAKE
FULCRUM
FORCE APPLIED TO THE CAR

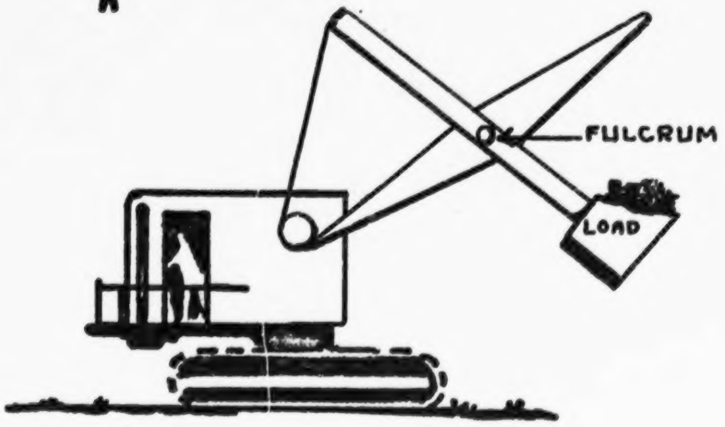
Part III

9. Which steam shovel below can lift the heaviest load? ______

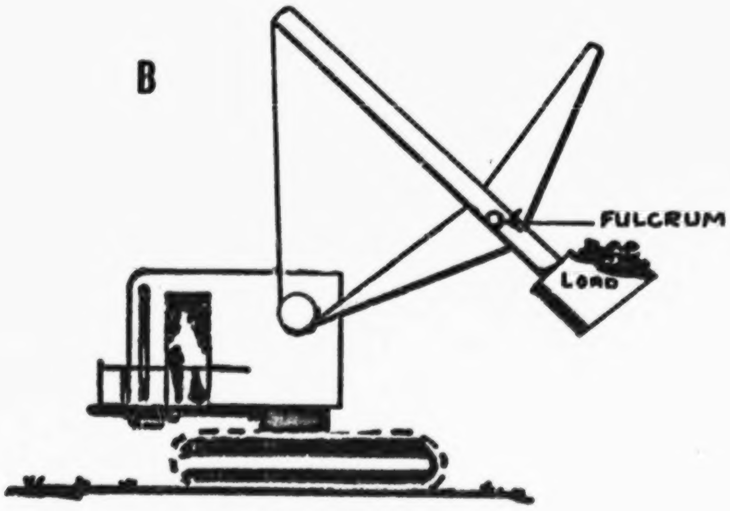
How did you decide which shovel lifts the heaviest load?

____

A

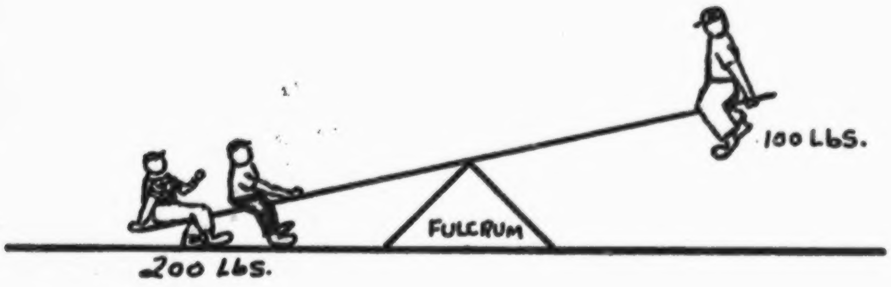

FULCRUM
LOAD

B


FULCRUM
LOAD

10. One boy on one end of a seesaw can lift 2 boys on the other end if the 2 boys move

______ a. closer to the fulcrum, making a shorter lever arm.
______ b. farther away from the fulcrum, making a longer lever arm.
______ c. to the extreme end of the lever arm.


100 LbS.
FULCRUM
200 LbS.

CODE FOR IDENTIFYING VARIABLES IN CORRELATIONAL MATRICES THAT FOLLOW

1. IQ
2. Verbal Reasoning
3. Abstract Reasoning
4. Spatial Relations
5. Time-to-Complete Preliminary Program on "Force"
6. Time-to-Complete Preliminary Program on "Introduction to Levers"
7. Sum of (5) and (6)
8. Pretest Scores on Levers
9. Posttest Scores on Levers
10. Retention Test Scores on Levers
11. Time-to-Complete on Self-Paced Portions of Lever Lesson
12. Recognition Responses
13. Editing Responses
14. Criterion Responses
15. Total Number of Responses

Errors on
Self-Paced
Lever Program

CORRELATIONAL MATRIX FOR THE GROUP RECEIVING THE VISUAL PRESENTATION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	M	SD	N
1		.401	.143	.206	-.505	-.508	-.595	-.056	.181	.157	-.467	-.084	-.057	-.175	-.131	106.783	7.086	46
2	46		.274	.229	-.308	-.088	-.240	.082	.457	.355	-.321	-.335	-.360	-.408	-.396	20.935	5.256	46
3	46	46		.567	-.140	.104	-.052	.265	.412	.393	-.009	-.211	-.231	-.333	-.290	30.609	7.185	46
4	46	46	46		-.198	-.029	-.197	.276	.366	.295	-.221	-.117	-.113	-.285	-.210	41.739	18.502	46
5	46	46	46	46		.525	.832	-.063	-.253	-.252	.640	-.043	.045	-.011	-.014	28.391	4.062	46
6	46	46	46	46	46		.847	.139	-.033	-.077	.458	-.161	-.084	-.168	-.161	29.652	6.916	46
7	46	46	46	46	46	46		.030	-.149	-.167	.612	-.112	-.015	-.121	-.106	57.609	9.171	46
8	46	46	46	46	46	46	46		.352	.364	.006	-.289	-.227	-.177	-.237	12.696	7.348	46
9	46	46	46	46	46	46	46	46		.825	-.187	-.542	-.447	-.549	-.560	39.000	7.951	46
10	46	46	46	46	46	46	46	46	46		-.075	-.459	-.480	-.476	-.498	37.804	8.719	46
11	46	46	46	46	46	46	46	46	46	46		.019	-.022	.067	.038	79.913	8.645	46
12	46	46	46	46	46	46	46	46	46	46	46		.848	.838	.948	6.457	5.736	46
13	46	46	46	46	46	46	46	46	46	46	46	46		.737	.892	2.630	2.689	46
14	46	46	46	46	46	46	46	46	46	46	46	46	46		.961	8.739	8.039	46
15	46	46	46	46	46	46	46	46	46	46	46	46	46	46		17.826	15.562	46

CORRELATIONAL MATRIX FOR THE GROUP RECEIVING THE VERBAL PRESENTATION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	M	SD	N
1		.563	.567	.437	-.390	-.316	-.372	.393	.309	.217	-.142	-.297	-.377	-.420	-.407	108.000	7.442	42
2	42		.521	.281	-.412	-.244	-.344	.197	.482	.479	-.286	-.230	-.159	-.311	-.284	21.548	7.439	42
3	42	42		.552	-.385	-.415	-.424	.283	.457	.215	.029	-.351	-.372	-.518	-.478	30.548	8.042	42
4	42	42	42		-.156	-.086	-.127	.343	.346	.073	.134	-.100	-.182	-.221	-.184	39.833	19.547	42
5	42	42	42	42		.785	.940	-.300	-.242	-.104	.636	.231	.153	.329	.292	29.881	4.387	42
6	42	42	42	42	42		.949	-.151	-.163	.067	.592	.028	-.029	.229	.114	28.857	4.754	42
7	42	42	42	42	42	42		-.236	-.213	-.016	.649	.133	.062	.294	.211	58.738	8.636	42
8	42	42	42	42	42	42	42		.419	.093	-.123	-.335	-.171	-.412	-.384	15.429	7.397	42
9	42	42	42	42	42	42	42	42		.563	-.120	-.358	-.220	-.544	-.464	37.500	8.010	42
10	42	42	42	42	42	42	42	42	42		-.048	-.213	-.288	-.372	-.327	33.476	9.786	42
11	42	42	42	42	42	42	42	42	42	42		-.215	-.126	.076	-.093	75.286	9.379	42
12	42	42	42	42	42	42	42	42	42	42	42		.536	.742	.926	9.762	6.931	42
13	42	42	42	42	42	42	42	42	42	42	42	42		.537	.692	3.310	2.641	42
14	42	42	42	42	42	42	42	42	42	42	42	42	42		.919	8.667	6.549	42
15	42	42	42	42	42	42	42	42	42	42	42	42	42	42		21.738	14.263	42

CORRELATIONAL MATRIX FOR THE CONTROL GROUP

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	M	SD	N
1		.645	.165	.549	-.372	-.449	-.469	.167	.449	.331	.178	-.177	-.139	-.128	-.164	108.022	6.849	45
2	45		.201	.434	-.453	-.544	-.568	.358	.510	.470	-.155	-.148	-.048	-.132	-.139	21.222	7.688	45
3	45	45		.503	-.086	-.325	-.251	.387	.344	.294	.063	-.088	-.115	-.214	-.164	29.400	8.507	45
4	45	45	45		-.122	-.389	-.340	.158	.436	.350	.114	-.132	-.067	-.141	-.139	42.778	19.929	45
5	45	45	45	45		.532	.770	-.354	-.237	-.170	.565	.164	-.010	.180	.160	28.533	4.607	45
6	45	45	45	45	45		.939	-.318	-.493	-.305	.320	-.128	-.125	.020	-.066	29.444	6.972	45
7	45	45	45	45	45	45		-.360	-.423	-.274	.477	-.026	-.110	.090	.016	58.200	10.260	45
8	45	45	45	45	45	45	45		.383	.233	-.309	.051	.124	.102	.093	13.222	7.055	45
9	45	45	45	45	45	45	45	45		.753	.044	-.070	-.227	-.185	-.160	33.867	12.278	45
10	45	45	45	45	45	45	45	45	45		.005	-.128	-.203	-.406	-.291	32.222	13.740	45
11	45	45	45	45	45	45	45	45	45	45		.072	-.093	.092	.063	76.867	7.915	45
12	45	45	45	45	45	45	45	45	45	45	45		.756	.719	.921	5.956	6.673	45
13	45	45	45	45	45	45	45	45	45	45	45	45		.677	.832	2.289	2.464	45
14	45	45	45	45	45	45	45	45	45	45	45	45	45		.924	9.556	7.541	45
15	45	45	45	45	45	45	45	45	45	45	45	45	45	45		17.800	15.162	45

APPENDIX B

Study #2

Page No.

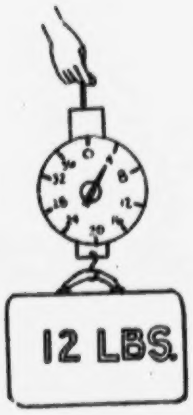
1. Visual Review Answer Booklet. B-1
2. Achievement Tests B-8

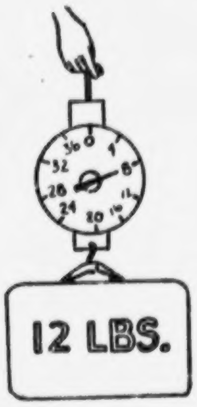
Study #2

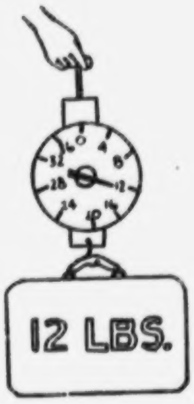
VISUAL REVIEW ANSWER BOOKLET

Page 1

☐ ☐ ☐

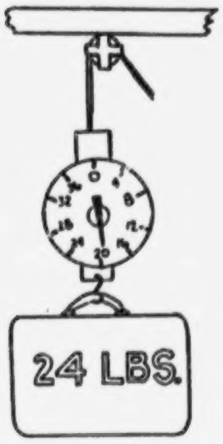


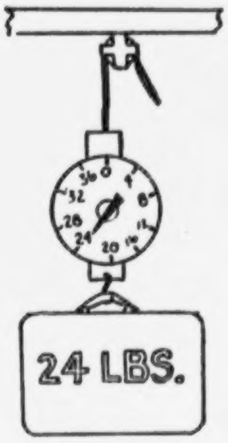


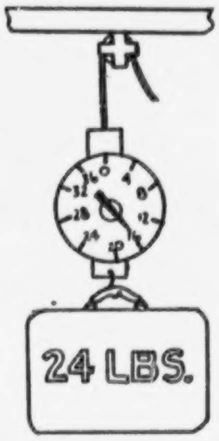


Page 2

☐ ☐ ☐

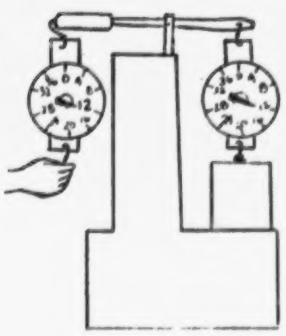


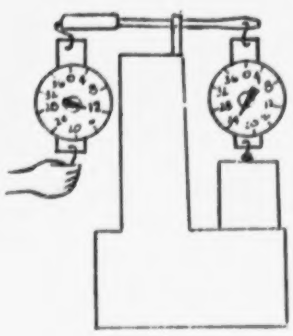




Page 3

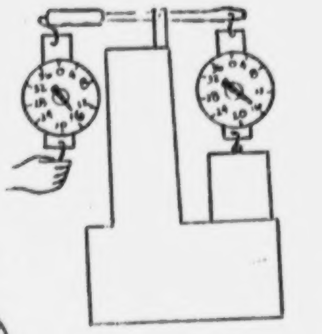
☐ ☐



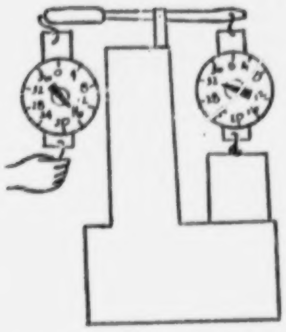


Page 4

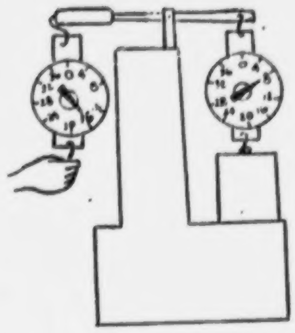
☐



☐

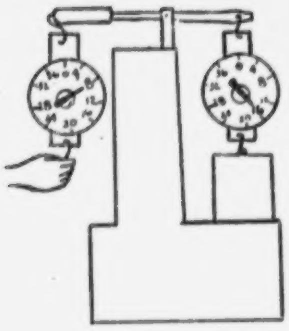


☐

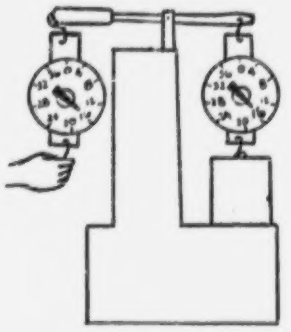


Page 5

☐

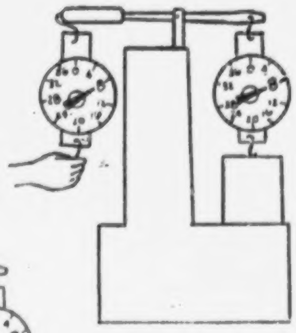


☐

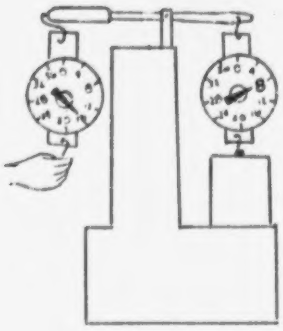


☐

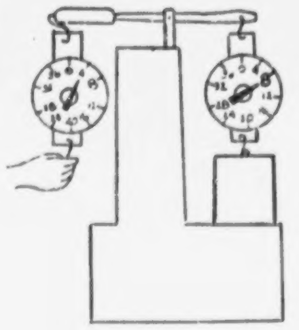
Page 6



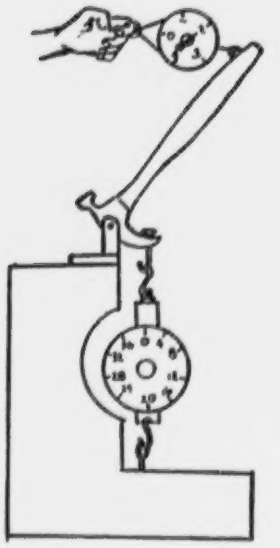
☐



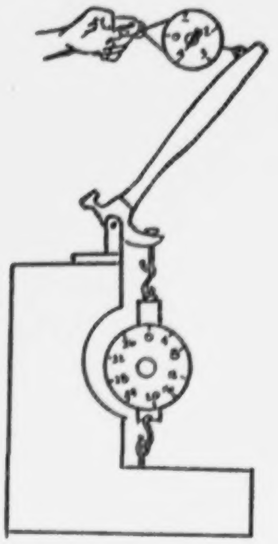
☐



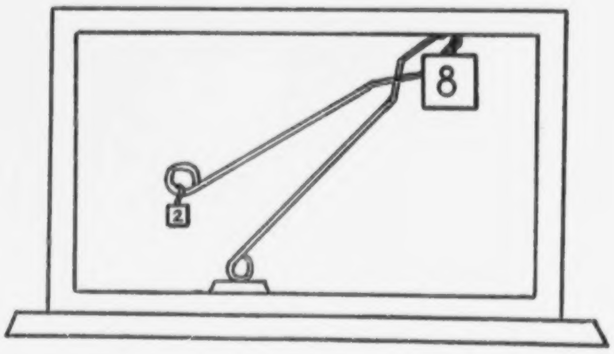
Page 7



Page 8



Page 9

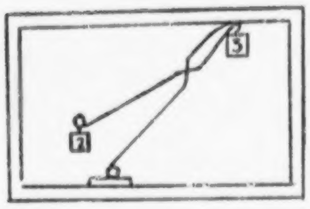


The effort force has been increased _______ times.

The mechanical advantage of the tongs is _______.

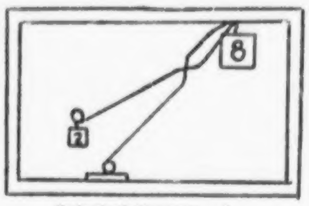
Page 10

☐



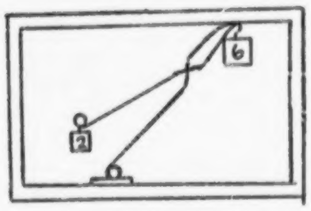
Mechanical Advantage = 3

☐



Mechanical Advantage = 3

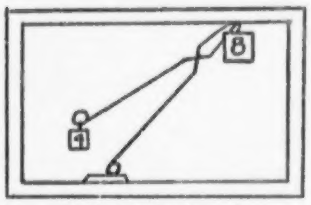
☐



Mechanical Advantage = 3

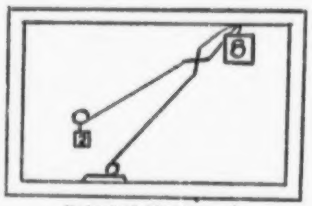
Page 11

☐



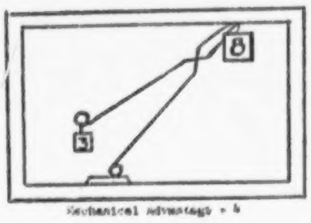
Mechanical Advantage = 4

☐



Mechanical Advantage = 4

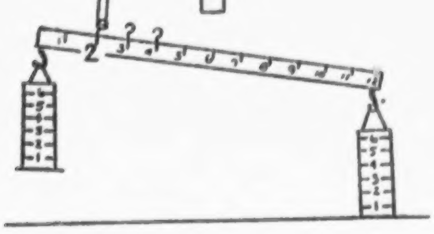
☐



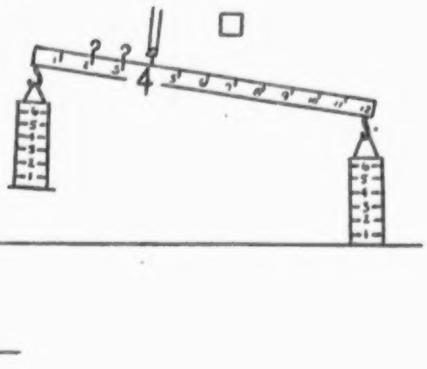
Mechanical Advantage = 4

Page 12

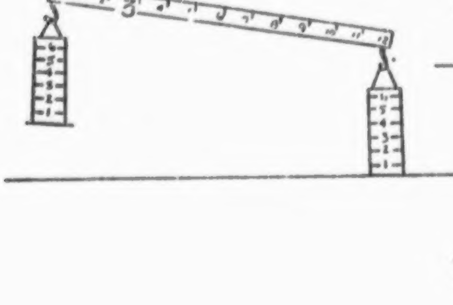
☐



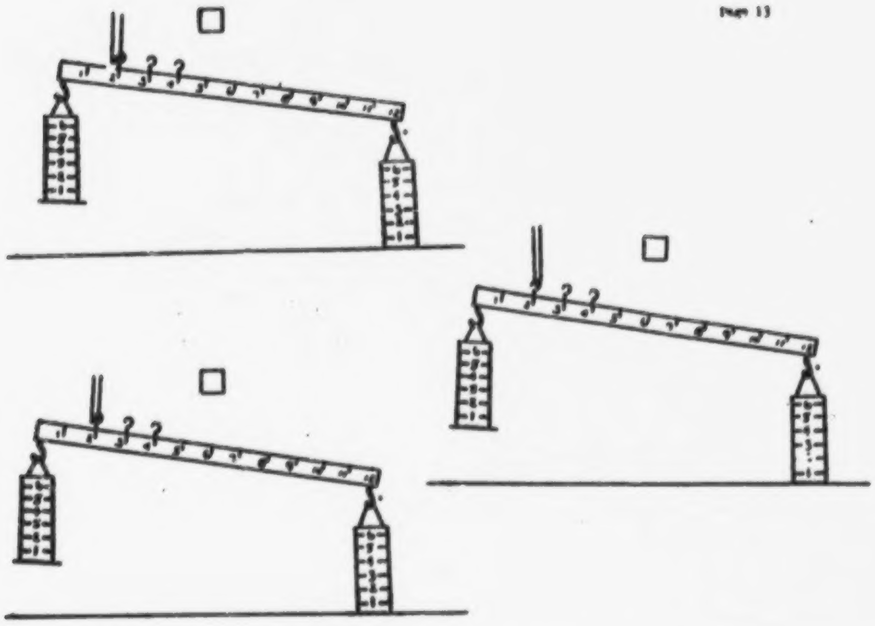
☐



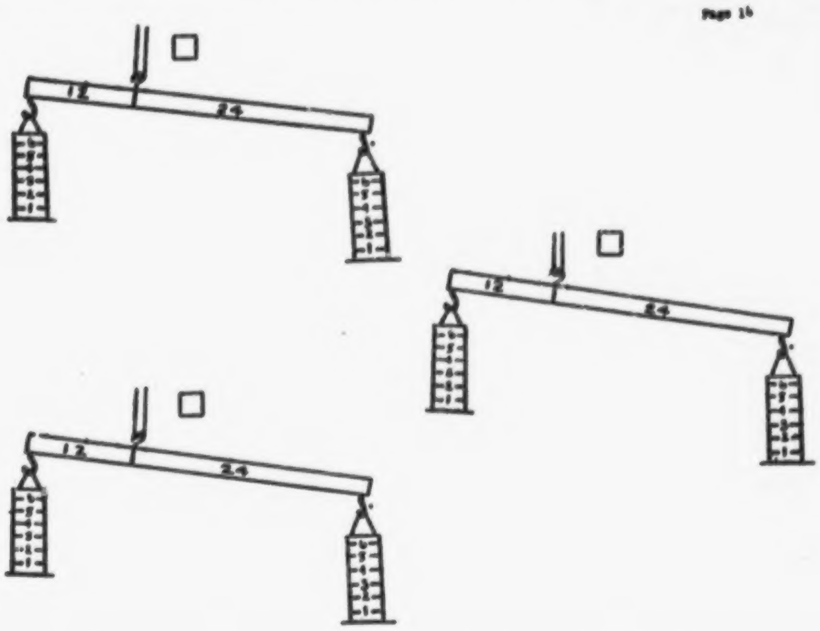
☐



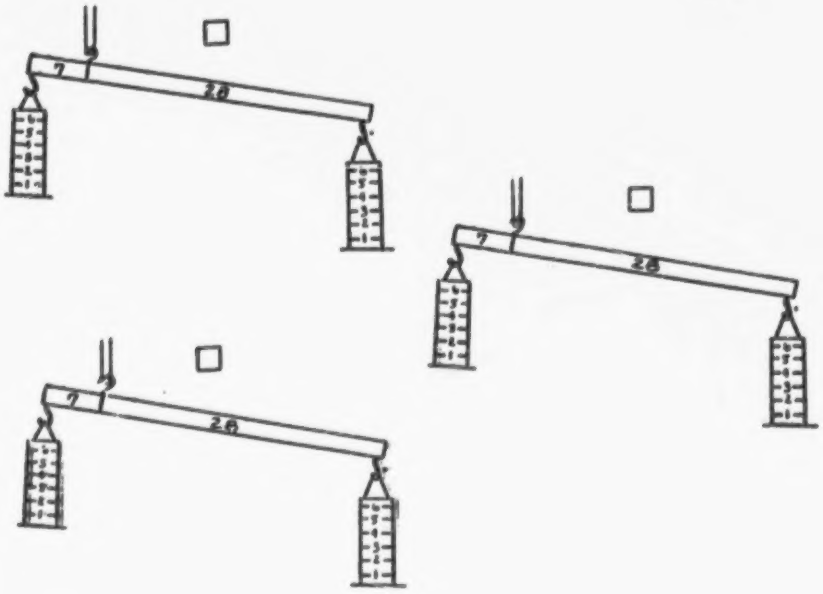
Page 13



Page 14

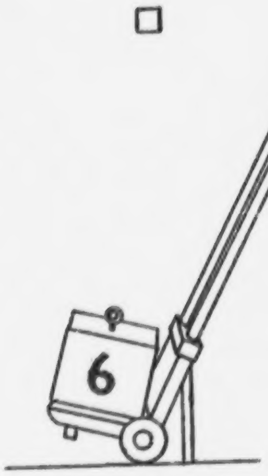

12
24
12
24
12
24

Page 15

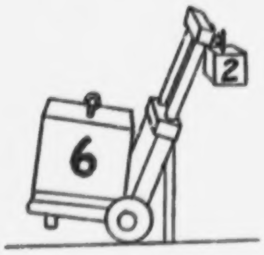


Page 16

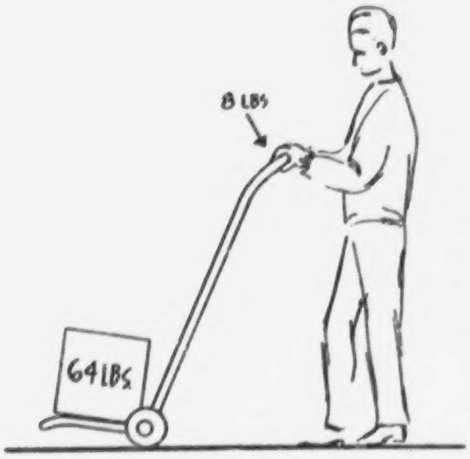
☐



☐

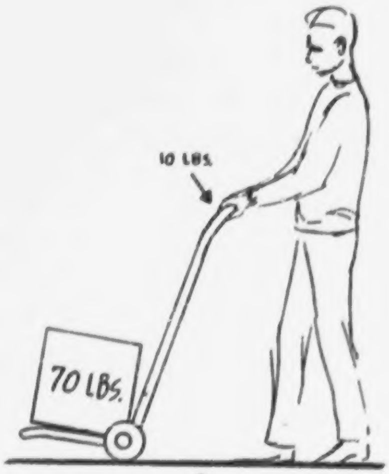


Page 17



A

Mechanical Advantage = _____


10 LBS.
70 LBS.

B

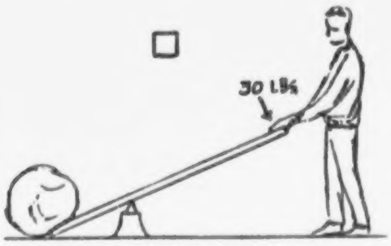
Mechanical Advantage = _____

Put an X next to the hand-truck which has more mechanical advantage

---

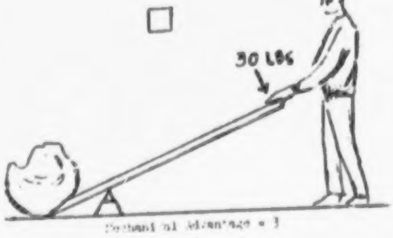
Page 18

☐



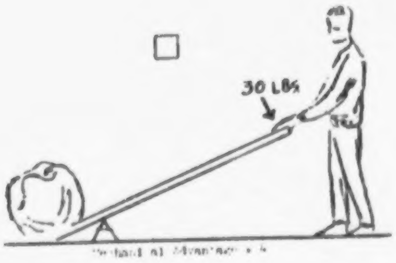
Mechanical Advantage = 2

☐



Mechanical Advantage = 3

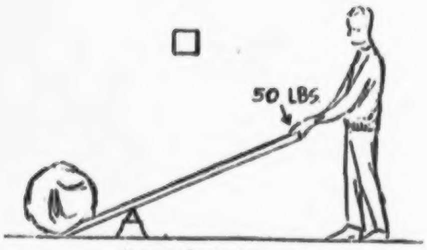
☐



Mechanical Advantage = 4

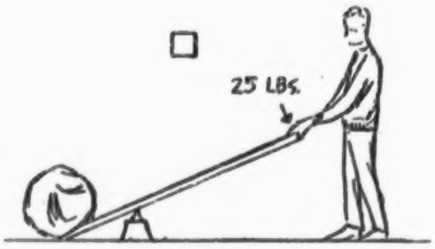
Page 19

☐



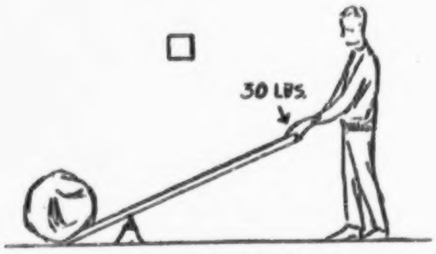
Mechanical Advantage = 3

☐



Mechanical Advantage = 3

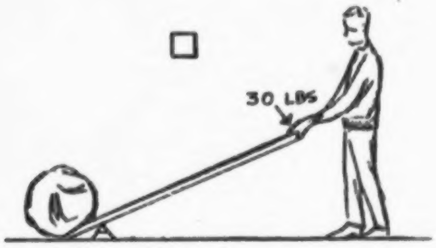
☐



Mechanical Advantage = 3

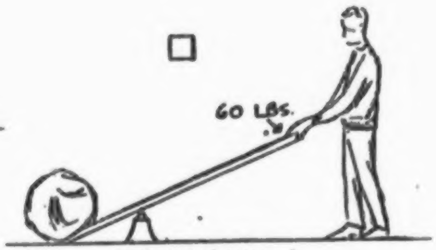
Page 20

☐



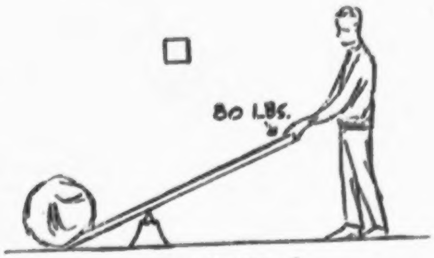
Mechanical Advantage = 5

☐



Mechanical Advantage = 3

☐



Mechanical Advantage = 2

Pre-Test - Study #2

ACHIEVEMENT TEST

Part I

A man wanted to buy an automobile jack so that, whenever he had a flat tire, he could jack up his car. Without a jack, he isn't able to lift the car at all. But, he can raise the car off the ground with a jack, because a jack is a lever.

1. When a man doesn't have a jack, the force he applies directly to the car usually isn't strong enough to raise the car. But, when he applies the same amount of force to the handle of a jack, the lifting part of the jack does apply a strong enough force to the car to lift it off the ground.

   Explain how a lever, like the jack, can produce enough force to lift the car.

   ____

   ____

   ____

2. When the man went to buy a jack, he had three different jacks to choose from. He wanted to choose the jack which would require him to apply the least amount of force to the handle.

   What would he have to find out about the three jacks in order to decide which jack would let him use the least amount of force?

   ____

   ____

   ____

3. The man chose one of the three jacks and he was able to lift his car with it. Later on, he bought a new car which was heavier than the one he had before. He wanted to keep on using the same jack.

   He found that, without making any changes in the jack, he could raise the heavier car by

   ____

   ____

4. The man's son was playing with the jack and added a strong stick to the jack handle. This made the handle longer than before. He found out that by making the handle longer, he could lift the car even though he was applying less force to the handle than before.

   Why? ____

   ____

5. The man's son could have made a different change in the jack which would also have let him apply less force to the handle than before.

   a. What change could he have made in the jack? ____________________

   ____

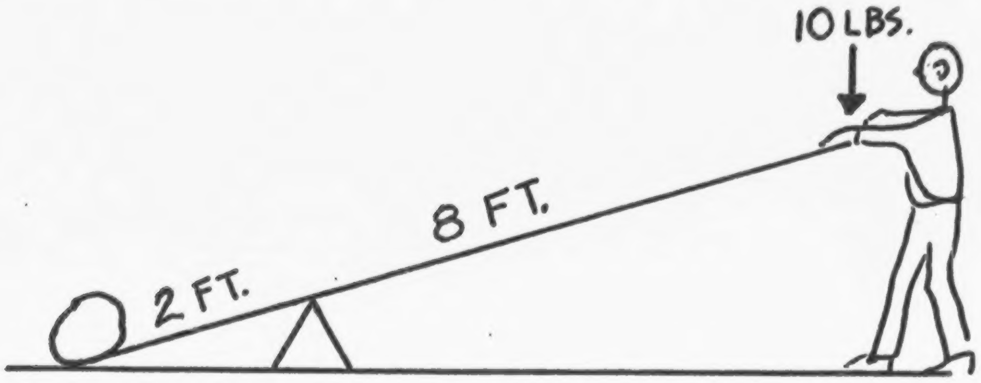
   b. Why would this change let him use less effort force than before?

   ____

   ____

Part II - Fill-ins

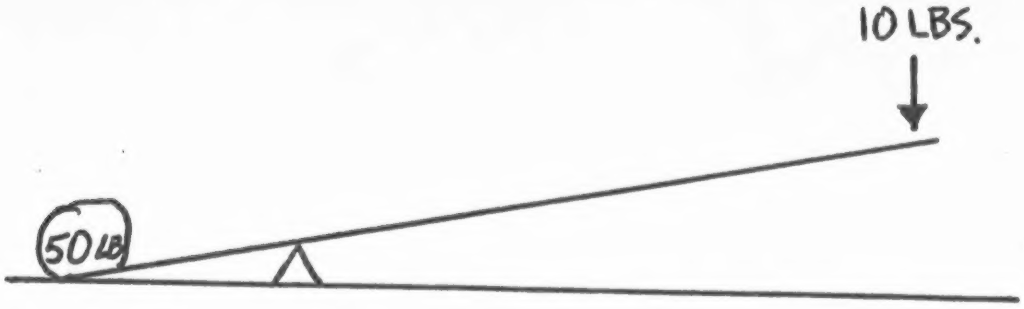
1. With an effort force of 10 lbs., the man can lift a load that weighs _____ lbs.



----

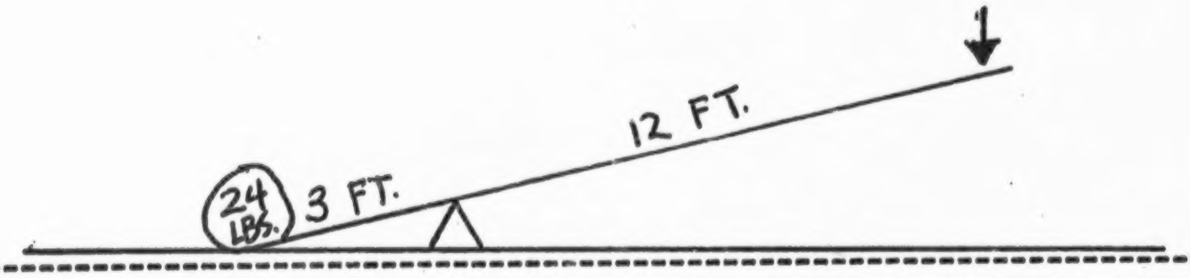
2. If a man had applied an effort force of 20 lbs. to the lever below instead of just 10 lbs., how big a load could he lift?

   He could lift a load weighing ______________.



3. In the picture below, how much effort force will be needed to lift the load?

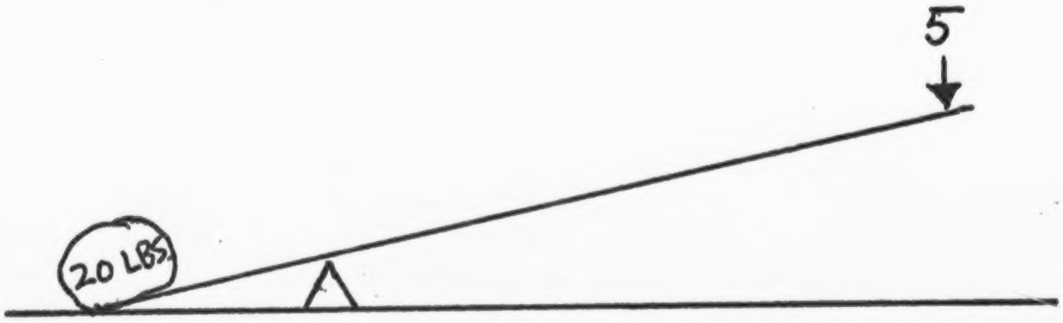
____



4. If we only applied a 5-lb. effort force to one end of the lever, why are we able to lift a 20-lb. load at the other end?

____

____



5. If we know what the mechanical advantage of a lever is, what does this information tell us about what we can do with that particular lever?

____

____

Part III - Multiple Choice - Put an X next to the one correct answer for each question.

1. The following five levers are all equally long. Which one of them has the fulcrum closest to the load?

			Load	Effort Force
_____	Lever A	⟶	100 lbs.	50 lbs.
_____	Lever B	⟶	10 lbs.	2 lbs.
_____	Lever C	⟶	9 lbs.	3 lbs.
_____	Lever D	⟶	70 lbs.	7 lbs.
_____	Lever E	⟶	48 lbs.	6 lbs.

2. Which of the following five levers will require the smallest effort force to lift their loads?

		Load	Mechanical Advantage
_____	Lever A	60 lbs.	6
_____	Lever B	25 lbs.	5
_____	Lever C	32 lbs.	4
_____	Lever D	21 lbs.	3
_____	Lever E	50 lbs.	2

3. Which of the following five levers has the largest mechanical advantage?

		Load	Effort Force
_____	Lever A	10 lbs.	2
_____	Lever B	20 lbs.	4
_____	Lever C	30 lbs.	3
_____	Lever D	40 lbs.	5
_____	Lever E	50 lbs.	10

4. In order to lift a 100-lb. load, which of the following five levers will require the least effort force?

		Lever Arm	Effort Arm
_____	Lever A	2	6
_____	Lever B	1	7
_____	Lever C	3	9
_____	Lever D	5	5
_____	Lever E	2	4

5. If a 10-lb. effort force is applied to the following five levers, which lever will lift the largest load?

		Lever Arm	Effort Arm
_____	Lever A	6	6
_____	Lever B	2	8
_____	Lever C	4	12
_____	Lever D	3	15
_____	Lever E	1	9

6. The mechanical advantage of a lever will be reduced by

_____ applying a larger effort force.

_____ applying a smaller effort force.

_____ reducing the weight of the load.

_____ increasing the distance between the fulcrum and load.

_____ decreasing the distance between the fulcrum and load.

7. We use levers because they have mechanical advantage. This means that by applying a certain amount of force to the lever, we can lift a load whose weight is

_____ less than the force we applied to the lever.

_____ equal to the force we applied to the lever.

_____ greater than the force we applied to the lever.

8. A man can lift a 25-lb. box with an effort force of 5 lbs. If he moved the fulcrum farther away from the load, he would then use

_____ less effort force.

_____ more effort force.

_____ the same amount of effort force.

9. The amount of mechanical advantage a lever has depends on

_____ the length of the lever arm.

_____ the length of the effort arm.

_____ the number of times the lever arm is longer than the effort arm.

_____ how heavy the load is.

_____ how strong the effort force is.

Retention Test - Study #2

ACHIEVEMENT TEST

PART I - Fill-ins

1. When a man tries to lift an automobile, the force he applies directly to the automobile usually isn't strong enough to raise the car.

   Explain how when a man uses an automobile jack, he can produce enough force to lift the car.

2. When a man went to buy an automobile jack, he had three different jacks to choose from. He wanted to choose the jack which would require him to apply the least amount of force to the handle.

   What would he have to find out about the three jacks in order to decide which jack would let him use the least amount of force?

3. The man chose one of the three jacks and he was able to lift his car with it. Later on, he bought a new car which was heavier than the one he had before. He wanted to keep on using the same jack.

   He found that, without making any changes in the jack, he could raise the heavier car by

4. The man's son was playing with the automobile jack and added a strong stick to the jack handle. This made the handle longer than before. He found out that by making the handle longer, he could lift the car even though he was applying less force to the handle than before.

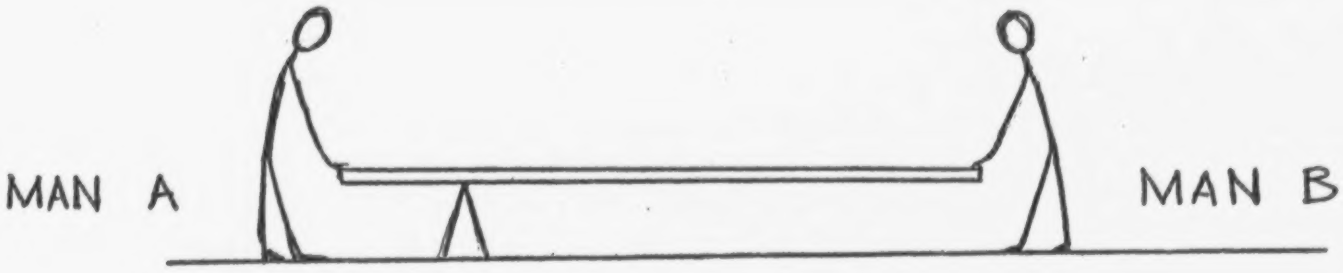
   Why?

5\.

(a) Two men are having a contest to see which one can push his own end of the board down to the ground. Which man will win when both men apply equal effort forces?

Man ________ Why? ____

____



(b) In order to make the contest between the two men to come out a tie, what should we do to the board?

____

6. Which steam shovel below can lift a heavy load with less effort force?

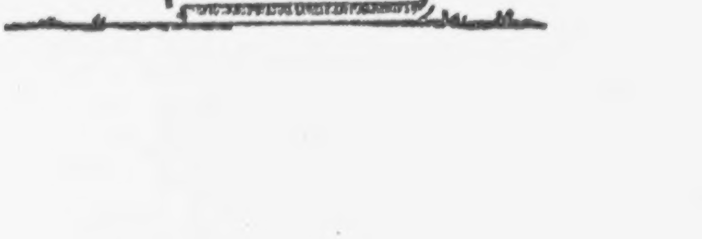
____

How did you decide which shovel can lift a heavy load with less effort force?

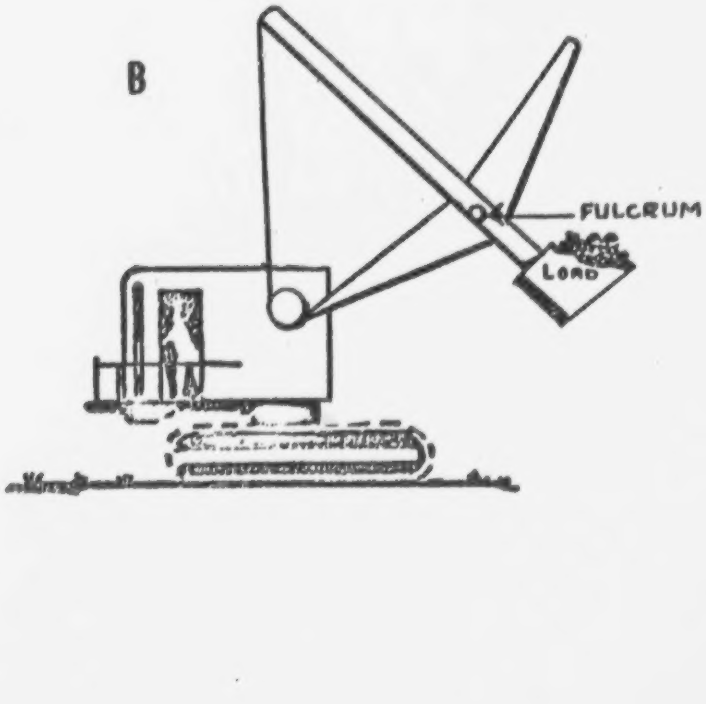
____

____

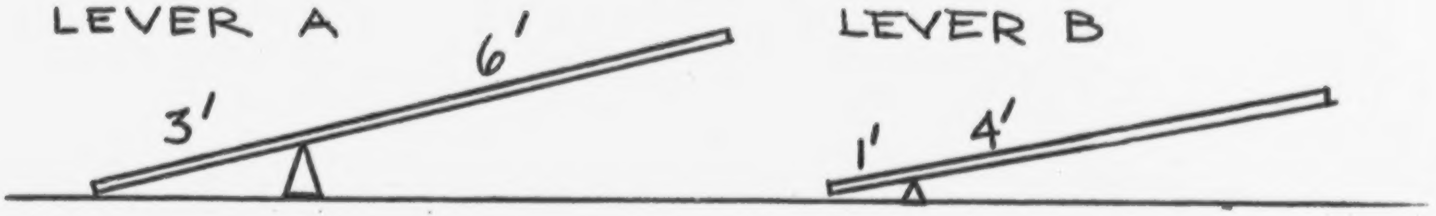
A



B



7.

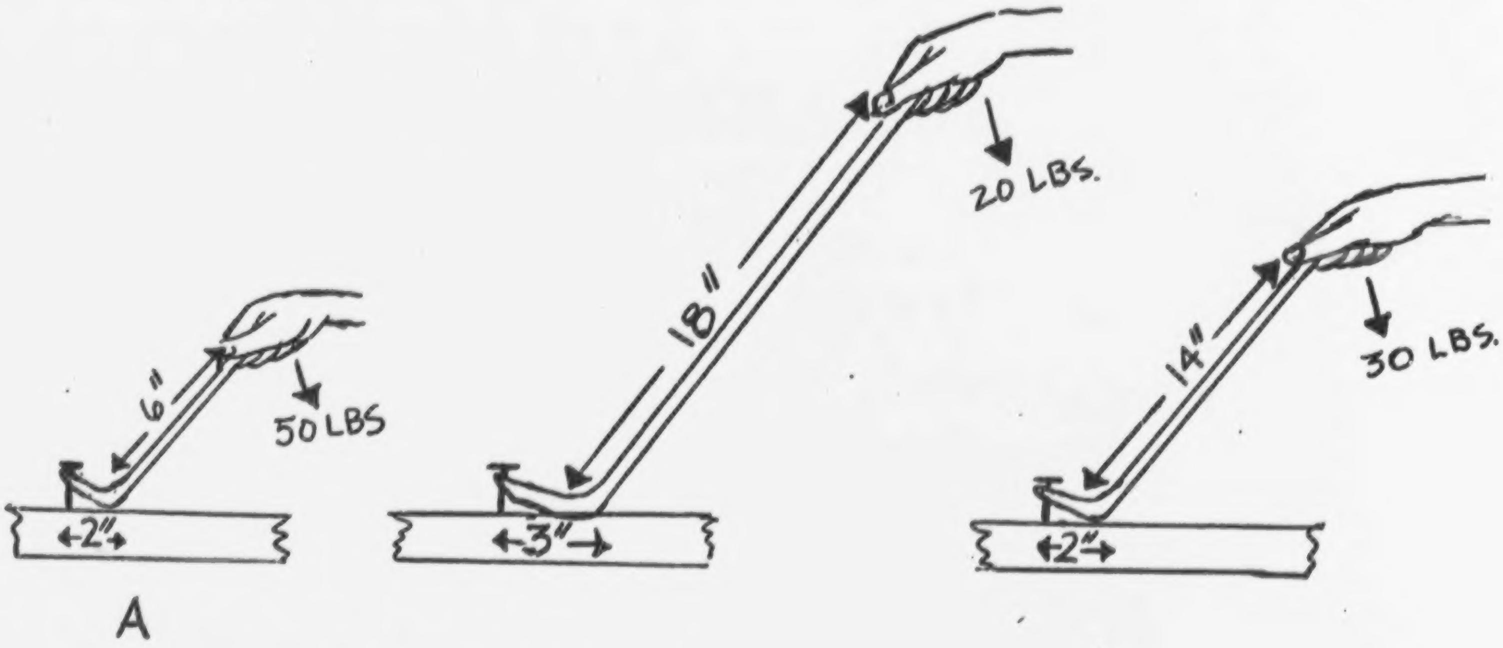

LEVER A
3'
6'
LEVER B
1'
4'

Lever A is larger and heavier than lever B, yet it has a smaller mechanical advantage. Explain how this can be.

____

____

8.


6"
50 LBS
2"
A
18"
20 LBS.
3"
14"
30 LBS.
2"

Each man is pulling down on the wrecking-bar as hard as he can pull in order to pry up a nail.

(a) Give the mechanical advantage of each bar, and the amount of force applied to each nail.

Mechanical Advantage	Force Applied to Nail
Bar A = __________	Nail A = __________
Bar B = __________	Nail B = __________
Bar C = __________	Nail C = __________

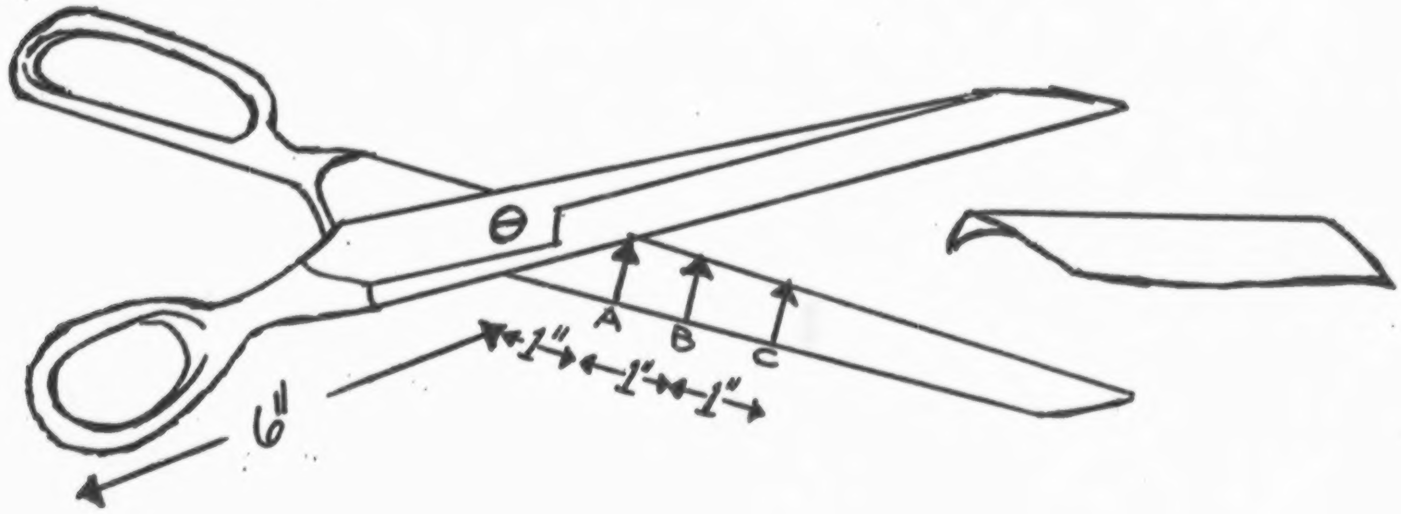
9. You can apply 10 lbs. of squeezing force to the handles of the scissors shown below.

If the edge of a piece of cloth were placed inside the blades, the amount of force applied to it at each position on the blades would be:

A = __________ lbs.

B = __________ lbs.

C = __________ lbs.



10. What does "mechanical advantage" mean?

PART II - Multiple Choice

Put an X next to the one correct answer for each question.

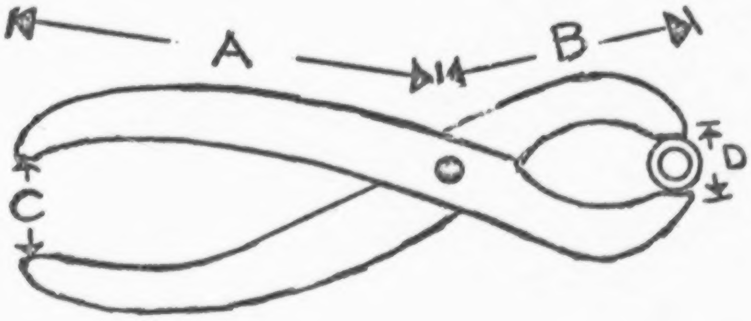
1. In order to calculate how much force is applied to the ring when a 5-lb. force is applied to the handles of the pliers, the distances we would need to know are

____ A and B.

____ B and C.

____ C and D.

____ D and A.



2. The following five levers are all equally long. Which one of them has the fulcrum closest to the load?

		Load Lifted	Effort Force Applied
____	Lever A →	100 lbs.	50 lbs.
____	Lever B →	10 lbs.	2 lbs.
____	Lever C →	9 lbs.	3 lbs.
____	Lever D →	70 lbs.	7 lbs.
____	Lever E →	48 lbs.	6 lbs.

3. Which of the following five levers will require the smallest effort force to lift their loads?

		Load	Mechanical Advantage
____	Lever A	60 lbs.	6
____	Lever B	25 lbs.	5
____	Lever C	32 lbs.	4
____	Lever D	21 lbs.	3
____	Lever E	50 lbs.	2

4. Which of the following five levers has the largest mechanical advantage?

		Load Lifted	Effort Force Applied
_____	Lever A	10 lbs.	2 lbs.
_____	Lever B	20 lbs.	4 lbs.
_____	Lever C	30 lbs.	3 lbs.
_____	Lever D	40 lbs.	5 lbs.
_____	Lever E	50 lbs.	10 lbs.

5. In order to lift a 100-lb. load, which of the following five levers will require the least effort force?

		Length of Lever Arm	Length of Effort Arm
_____	Lever A	2 ft.	6 ft.
_____	Lever B	1 ft.	7 ft.
_____	Lever C	3 ft.	9 ft.
_____	Lever D	5 ft.	5 ft.
_____	Lever E	2 ft.	4 ft.

6. If a 10-lb. effort force is applied to the following five levers, which lever will lift the largest load?

		Length of Lever Arm	Length of Effort Arm
_____	Lever A	6 ft.	6 ft.
_____	Lever B	2 ft.	8 ft.
_____	Lever C	4 ft.	12 ft.
_____	Lever D	3 ft.	15 ft.
_____	Lever E	1 ft.	9 ft.

7. The mechanical advantage of a lever will be reduced by

_____ applying a larger effort force.

_____ applying a smaller effort force.

_____ reducing the weight of the load.

_____ increasing the distance between the fulcrum and load.

_____ decreasing the distance between the fulcrum and load.

8. We use levers because they have mechanical advantage. This means that by applying a certain amount of force to the lever, we can lift a load whose weight is

_____ less than the force we applied to the lever.

_____ equal to the force we applied to the lever.

_____ greater than the force we applied to the lever.

9. A man can lift a 25-lb. box with an effort force of 5 lbs. If he moved the fulcrum farther away from the load, he would then use

_____ less effort force.

_____ more effort force.

_____ the same amount of effort force.

10. The amount of mechanical advantage a lever has depends on

_____ the length of the lever arm.

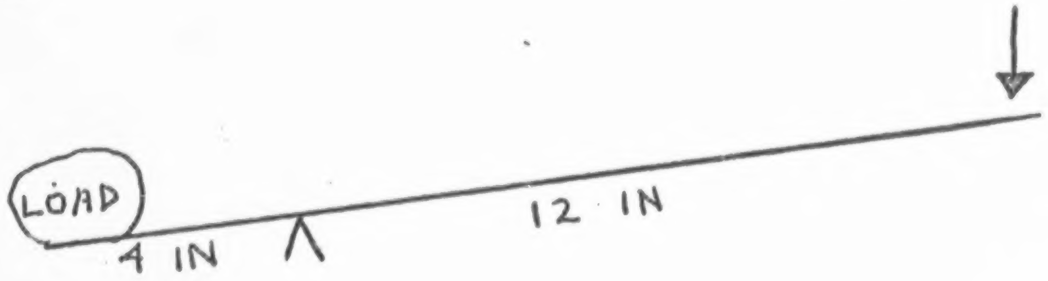
_____ the length of the effort arm.

_____ the number of times the effort arm is longer than the lever arm.

_____ how heavy the load is.

_____ how strong the effort force is.

11.



When we use this lever, the effort force will be

_____ 1/4 as big as the load.

_____ 1/3 as big as the load.

_____ 3 times bigger than the load.

_____ 4 tims bigger than the load.

_____ equal to the load.